Series 1936, No. 2 Issued March 1940

Soil Survey

Major County Oklahoma

By
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and
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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
Oklahoma Agricultural Experiment Station

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SOIL SURVEY OF MAJOR COUNTY, OKLAHOMA

By W. H. BUCKHANNAN, Division of Soil Survey,[1] Bureau of Plant Industry, United States Department of Agriculture, in Charge, and O. H. BRENSING and C. F. FISHER, Oklahoma Agricultural Experiment Station

Area inspected by W. T. CARTER, Inspector, District 4

United States Department of Agriculture in cooperation with the Oklahoma Agricultural Experiment Station

COUNTY SURVEYED

Major County is in northwestern Oklahoma, about 40 miles south of the Kansas State line and 60 miles east of the Texas State line (fig. 1). Fairview, the county seat, is about 80 miles northwest of Oklahoma City. The county includes an area of 954 square miles, or 610,560 acres.

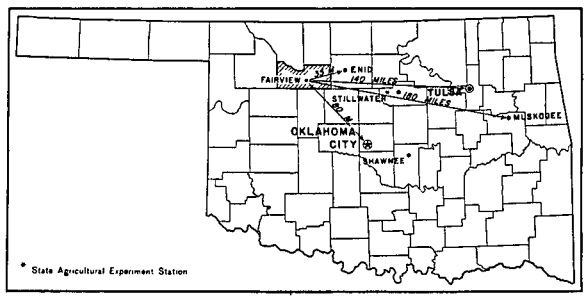

FIGURE 1.—Sketch map showing location of Major County, Okla.

This county lies in the Great Plains province near the eastern side of the western section of the "Red Beds" Plains. Physiographically, it consists of two plains separated by an escarpment extending across the county in a southeasterly direction from the northwestern corner to the south-central part. In the northwestern part, where the escarpment is more pronounced, the difference in elevation between the upper plain and the lower plain is about 175 feet. In the southern half, the difference in elevation between these plains is less and the slope between them is not so steep. In places, high steep bluffs form the escarpment in the northwestern part. The bluffs stand out prominently between the V-shaped valleys, and large areas along the escarpment are so severely eroded as to present typical badland features.

The higher plain west of the escarpment is deeply dissected for a distance ranging from 5 to 10 miles back from the escarpment by streams that have their origin in the covering of deep sand on the higher plains. The relief everywhere in this drainage area is destructional, and along the valley sides and lower slopes the surface

[1] The field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils.

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is deeply eroded. Natural surface drainage is incomplete in the southern part of the upper plain, except along the North Canadian River, which traverses the southwestern corner of the county, and along the small tributaries south of the river. In this sand-hill section drainage channels are absent, most of the drainage is effected downward through the porous substrata, and the relief, except along the North Canadian River, is rolling to hummocky. The surface has been modified chiefly by the wind, which has shifted the sandy material and piled it into low ridges and dunelike elevations, practically all of which are now stabilized by native vegetation.

The lower plain slopes gently from the escarpment northeastward toward the Cimarron River, which roughly parallels the escarpment across the county. The river forms the western half of the northern boundary of the county. The surface of the plain between the river and the escarpment, in general, is rather smooth but is dissected by streams issuing from the upper plain. Some of the smaller streams spread out over the plain, as they emerge from the escarpment, and deposit, in places, thin layers of fine-textured soil materials. Between the streams immediately below the escarpment are many bench-like areas, which are, as a rule, gently undulating. In some of these areas surface drainage is rapid, and accelerated erosion is active. In a few areas near the bottom lands of the Cimarron River drainage is slow.

Just north of the Cimarron River in the eastern part of the county is a large area of sandy undulating country similar to the belt of sand hills on the higher plain. This area is dissected by small streams issuing from the plain in the northeastern part of the county. Narrow areas of sandy lands, consisting of a succession of irregularly distributed small hills and ridges of dunelike form, ranging from 15 to 50 feet in height, occur along the northern sides of the North Canadian and Cimarron Rivers. They are most extensive along the latter stream.

The plain in the northeastern part of the county, in general, is smooth, with comparatively small flat areas lying between more thoroughly dissected areas. The level areas are parts of the original plain, on which drainage channels have not encroached. Steep and severely eroded areas are few in this part of the county.

The elevation above sea level at Fairview, which is on the lower plain, is 1,292 feet. The general slope of the land is southeasterly and parallel to the Cimarron River, but local drainage is effected mainly through small tributaries that flow at right angles to that stream. The Cimarron River has a fall of about 6 feet to the mile.

The native vegetation on the smooth areas of heavy soils, which are mostly in the western and central parts of the county, consists of an almost pure stand of short grasses, including buffalo grass and blue grama, with buffalo grass predominating. The vegetation in the eastern part of the county, where it has not been heavily grazed, consists dominantly of coarse bunchgrasses, largely prairie beardgrass and bluejoint turkeyfoot, locally called little bluestem and big bluestem, respectively, with some buffalo grass, side-oats grama, blue grama, and others.

The varieties of grasses and the denseness of the grass cover along the escarpment on the eroded areas and areas receiving outwash of heavy material from rough lands are less uniform than on the smoother areas where the soils are older. On some of these areas bluestem (western wheatgrass) predominates, but dropseed, switchgrass, side-oats grama, three-awn (wire grass), and other grasses are abundant. These grasses also grow in narrow strips of bottom lands along the streams issuing from the upper plain, and along the bottom lands of the Cimarron River.

The lighter soils of the upland also have a more varied vegetation. The native vegetation consists largely of bunchgrass, prairie beardgrass, and Indian grass, with small quantities of sand dropseed, switchgrass, buffalo grass, blue grama, side-oats grama, and wire grass.

Saltgrass predominates in some areas on bottom lands along the Cimarron River, as well as on many of the eroded areas below the escarpment where saline conditions occur. In some pastures many kinds of weeds have intruded as a result of overgrazing.

The prevailing forest growth is of three broad types: (1) A scattered growth of mesquite on the heavier soils of the upland; (2) a growth consisting mostly of blackjack oak on the very sandy soils, with some dwarf oaks, locally called shin oaks, in the western part of the county; and (3) a mixed growth on first bottoms and some steep slopes, consisting chiefly of elm, cottonwood, hackberry, and ash. Two large areas are thickly covered with blackjack oak. One of these is in the southwestern part of the county, and the other is in the eastern part, east of the Cimarron River. Besides the blackjack oak in these areas are bur oak and shin oak. Trees, brush, and other plants along the deeper canyons of the sandy Permian "Red Beds" include elm, green ash, hackberry, cedar, buckbrush, smooth sumac, wild plum, grapes, dogwood, poison-ivy, and pricklypear. Wild plums and grapes grow abundantly along the North Canadian River. Some planted groves of trees afford protection to farm homes and schools.

Prior to the arrival of white men this part of Oklahoma was occupied by the Comanche Indians. At the time of the Louisiana Purchase in 1803 it was claimed by the Osage Indians, and later it became a part of the Cherokee Strip. Ranching was engaged in by white settlers as early as 1885, but the land was not formally opened for settlement until 1893, when the territory now included in Major County was organized as part of Woods County. Major County was given its present size and shape in 1907, and the first county seat, Fairview, was located at its present site.

A very large proportion of the first white residents were native Americans and came from Kansas, Missouri, Iowa, and Illinois. Some settlers of German descent live in the northeastern part of the county in the vicinity of Meno and northwest of Fairview.

Fairview is near the center of the county and, according to the 1930 census, has a population of 1,887. The only other incorporated towns are Cleo Springs, Ames, and Ringwood, all of which are east of the Cimarron River. Ringwood has a population of 265, Cleo Springs 356, and Ames 290. Meno and Isabella are small unincorporated

towns in the eastern part of the county. The total population of the county is 12,206, as reported by the 1930 census, of whom 9,045 are classed as rural-farm and 3,161 as rural-nonfarm. The population is well distributed, except in the northwestern part of the county and along the eastern side of the Cimarron River, where a large proportion of the land is nonarable.

Three railroads serve the eastern half of the county. The Atchison, Topeka & Santa Fe Railway crosses from north to south through the central part. It is roughly paralleled by one branch of the Chicago, Rock Island & Pacific Railway, another branch of which passes through Isabella and Meno. A line of the St. Louis-San Francisco Railway crosses the southeastern part through Ames.

The public-road system is good. United States Highway No. 60 connects Fairview, Cleo Springs, and Meno with Enid. About 16 miles of the roads are concrete highways, and other improved roads are in the process of construction. The dirt roads are graded, and the State and Federal highways are kept in good condition. During protracted rainy spells the clay roads are unfavorable for travel. Rural free delivery of mail and telephone lines reach all sections.

There are 7 high schools and 87 grade schools in the county. Some of the schools are consolidated. There are several large rural churches, chiefly in the German communities.

The supply of water from wells in the sandy sections is abundant, and the quality is very good. In the northwestern and central parts and in many places in the northeastern part, sufficient good water is difficult to obtain because of the underlying impervious Permian shale, which does not afford a good underground reservoir. Wherever the soil is underlain by sandstone good water is abundant. The wells in the sandy areas range from 30 to 100 feet in depth. Water in the alluvial soils along the Cimarron River is obtained at a depth ranging from 10 to 30 feet, but in places it is too salty for satisfactory use.

Many springs are along the V-shaped valleys in the west-central part of the county and in the sand hills east of the Cimarron River. Most of the springs east of the Cimarron River are near Cleo Springs and issue from the water-bearing sands above the Permian shale. Several artesian wells, each having a strong flow of good water, are drilled in the first bottoms along the Cimarron River north and east of Fairview. These wells range from 30 to 50 feet in depth.

CLIMATE

The climate is continental and, although mild, is more or less variable from year to year. Most of the winters are open, except a few days at a time, when cold waves and blizzards, locally called northers, sweep across the plains from the northwest. It is common in winter for cool or warm moderate southwesterly winds to blow from a few days to several weeks in succession. These stormy periods may be terminated very suddenly by a shift of the wind to the northwest and a sudden drop in temperature, accompanied by light snowfall. At these times the temperature reaches the minimum for the year, but

the extremely low temperatures rarely last more than 1 or 2 days. The northers are most severe during the latter part of December and in January and February. In March strong northwesterly winds are frequent, but the cold is less intense than that accompanied by the northers during the three previous months. The weather is warm and pleasant during April and May, but the most pleasant weather of the year usually is during the fall, when approximately the same temperature prevails and windy and rainy days are fewer than in spring. In summer, the days are hot, but the nights usually are comfortable. Periods of extremely hot and dry weather vary in length from a few days to several weeks and generally are accompanied by very hot winds from the south. These periods come with the greatest intensity during July and August and, during the driest years, cause severe damage to crops. Prevailing winds are southerly, except during winter, when the direction alternates from north to south with marked regularity.

Precipitation varies greatly from year to year. Generally it is heaviest during spring and summer when the growing crops are most in need of moisture. Although the amount of moisture in the soil carried over winter is important, good yields of crops depend not only on the amount of precipitation during the growing season but on the time at which it occurs. A comparatively low annual rainfall, properly distributed, may produce a good crop where a relatively high rainfall, unfavorably distributed, results in failure or low yield. Hence, records of average annual and monthly precipitation may be misleading because of the influence of the distribution of the precipitation. The amount of average precipitation is about 4 inches less in the western part of the county than in the eastern part.

Crops on the light-textured soils suffer less from prolonged droughts than those on the heavy-textured soils. In late spring and early summer, thunderstorms, characterized by short, heavy downpours, frequently occur and often damage the wheat. Summer rains, because of their torrential nature, cause destructive erosion on all the more pronounced slopes, especially where the ground has been plowed recently.

For the months of April, May, and June, the period when the amount of precipitation is important, the average total precipitation is 10.92 inches. In 7 years between 1905 and 1930 the total precipitation for these months was 2¼ inches less than the average.

The average dates of the latest and earliest killing frosts at Alva, about 50 miles north of Fairview, are April 4 and October 28, respectively, giving an average frost-free season of 207 days. Frost has been recorded at this station as early as September 23 and as late as May 15.

Since continuous records are not kept in the county, the more important climatic data, as recorded at the United States Weather Bureau station at Alva, Woods County, are given in table 1. These are fairly representative of conditions in Major County.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Alva, Woods County, Okla.*

[Elevation, 1,350 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1933)	Total amount for the wettest year (1915)	Snow, average depth
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	36.9	81	−7	0.98	0.36	0.14	4.1
January	34.7	81	−14	.80	.09	1.21	3.0
February	38.7	88	−14	1.16	.10	3.46	5.2
Winter	36.8	88	−14	2.94	.55	4.81	12.3
March	48.2	99	−1	1.54	.84	2.36	1.6
April	58.1	99	18	2.77	1.49	7.67	.1
May	66.7	105	25	4.50	1.37	8.16	0
Spring	57.7	105	−1	8.81	3.70	18.19	1.7
June	76.6	114	41	3.65	.12	7.78	0
July	81.2	114	51	2.90	1.78	2.42	0
August	80.7	112	45	3.38	5.44	5.16	0
Summer	79.5	114	41	9.93	7.34	15.36	0
September	73.4	105	31	3.04	2.06	3.45	0
October	60.4	99	10	2.33	1.28	3.62	(1)
November	47.7	86	5	1.70	.54	.32	.8
Fall	60.5	105	5	7.07	3.88	7.39	.8
Year	58.6	114	−14	28.75	15.47	45.75	14.8

[1] Trace.

AGRICULTURAL HISTORY AND STATISTICS

The first agricultural enterprise in Major County was cattle grazing, which was started by large companies about 1885. Prior to this time the land was used by the Indians as a hunting ground. The free open range supported a luxuriant growth of prairie grasses, and the wooded and canyonlike areas afforded shelter for the cattle during the winter. No crops were grown by the early ranchers, and the native grasses were depended on entirely as feed for livestock. In 1893, when the Strip was opened for settlement, the land was broken for the production of crops. Within a year after homesteading was begun, all the land suited for tillage, as well as almost all of the rough grazing land, was homesteaded.

Corn, wheat, oats, broomcorn, and grain sorghums have always been the most important crops. Although the type of agriculture practiced differs considerably in different parts of the county, wheat is the principal crop in practically all sections. A large proportion of the other field crops are fed to livestock. The production of wheat has expanded markedly since 1900, whereas the production of corn has contracted. The acreages of other crops, including rye, barley, grain sorghums, peas, peanuts, broomcorn, and hay crops, fluctuate from year to year. The acreage devoted to cotton has increased considerably in the last 15 years.

The marked increase in wheat acreage that has taken place since 1900 is due to more economical production and greater use of machinery. Combines are used commonly in those sections devoted

mainly to the production of wheat, but in sections where a diversified system of agriculture is practiced wheat is generally headed and threshed from the stack. The average yield of wheat in 1934 was about 12.4 bushels an acre, but yields vary because of the variable rainfall. Variations in yields over the county are affected not only by the decrease in rainfall from east to west, but also by great differences in the character of the soils. Hard winter wheat is grown principally, Turkey being the most popular variety, although some mixtures of Turkey, Kanred, and Blackhull are grown. During favorable seasons when wheat makes a good growth before killing frosts occur, fall and early winter pasture is afforded to a large number of cattle, which are shipped in from Texas. Most of the farmers in the large wheat-producing sections of the county grow wheat in the same fields for many years in succession. In sections having sandy soils, however, a rotation of sorghums, cotton, and wheat is in general use. In general, higher yields of wheat are obtained following cotton than following wheat or sorghums.

In the last few years, cotton has replaced wheat in certain sandy areas. Cotton withstands drought well, and the boll weevil has not infested this section. The chief varieties of cotton are Mebane and Oklahoma Triumph, and some Acala is grown. According to local information, the acre yields of cotton average about 160 pounds on the better soils.

The production of grain sorghums has declined somewhat since 1920, but it is the principal crop on most of the farms in the western section of the county, where the relief is rolling and red sandy soils predominate. It is reported that the average yield in this section is about 25 bushels an acre on the better soils. Many of the fields contain several mixtures and hybrids of sorghums (*7*).[2] The principal varieties grown are Dwarf Yellow milo, Standard Yellow milo, Dawn kafir, Reed kafir, Red kafir, Standard Blackhull kafir, Dwarf hegari, and feterita. Some preference is given to varieties of Dwarf milo because the varieties mature more quickly than the Standard milo.

Very little corn is grown because of the frequent low yields, although it was the most important crop in 1909. It is not uncommon for a very good stand of corn to be damaged by dry weather in the latter part of the summer. In 1929, a favorable year for corn, the average yield was only about 12.5 bushels an acre. The principal varieties are Reid Yellow Dent and Mexican June. All the corn is used locally, and large quantities are cut for fodder, especially during dry seasons when hot winds damage the corn after the tasseling period.

Alfalfa is the leading tame-hay crop. Little attention is given by farmers to the varieties grown, but probably most of the alfalfa is Grimm and Common. From 15 to 20 pounds of seed to the acre is used for seeding, and generally a stand is allowed to remain as long as it yields profitably. Most of the hay produced is used locally. In addition, alfalfa for seed was grown on 548 acres in 1929 and produced 783 bushels. Practically all of the rye is used on farms where it is produced. It is sown for winter pasture, hay, and grain. African millet produces well and is grown in the southwestern part of the county. It makes a quick growth and matures more often

[2] Italic numbers in parentheses refer to Literature Cited, p. 70.

during the dry seasons than most of the grain sorghums. Sudan grass is not grown by many farmers, although yields of forage are high, and this crop is especially valuable for grazing. Sorgo produces good yields of grain as well as roughage. Peanuts were grown on 175 acres in 1934. Most of the peanuts are produced in the eastern part of the county on the light sandy soils.

During the last 10 years the acreage of cowpeas has increased rapidly. Cowpeas are grown almost entirely on the sandy soils and are desirable for adding nitrogen to the soil. High yields of wheat are reported by farmers when the wheat follows cowpeas, but precautions must be taken to prevent the wind from blowing the surface soil if the cowpeas are cut and raked in harvesting. Wheat straw usually is spread on the surface to prevent blowing of the surface soil. Austrian Winter peas sometimes are grown, but most of the field peas consist of Red Ripper, Common, or a mixture of several varieties. The peas are used as cattle feed and for adding nitrogen to the sandy soils that are low in organic matter.

Most of the fruit is grown for local use. In 1929, on 23 farms, fruit was the source of more than 50 percent of the farm income. Pears, peaches, apples, cherries, blackberries, grapes, and plums are grown. The production of fruit, however, has declined in importance since 1910. The numbers of bearing fruit trees reported in 1935 were as follows: Pears 12,362, peaches 5,980, and apples 5,364; and the number of bearing grapevines was 8,478. Most of the early settlers planted fruit trees, but the lack of knowledge in selecting proper orchard sites and the irregularity of the crop have tended to discourage the production of fruit. Apples are the principal crop of the few small commercial orchards, and Jonathan, Grimes, Winesap, and Ben Davis are the leading varieties grown. A small quantity of pears of the Kieffer variety are produced. Peaches and plums do well in small home orchards. Fairly large total acreages are devoted to blackberries and watermelons.

Table 2 gives the acreages of the principal crops in the county, in the years 1909, 1919, 1929, and 1934, as reported by the Federal censuses.

TABLE 2.—*Acreages of the principal crops in Major County, Okla., in stated years*

Crop	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*
Wheat	31,831	124,799	155,033	129,556
Corn for grain	89,335	19,559	19,593	1,660
Corn for silage, fodder, and hogging down		[1] 3,947	1,998	3,763
Oats threshed	6,092	6,909	6,345	8,279
Oats, cut and fed unthreshed			564	2,015
Barley	171	1,519	1,262	2,920
Cotton	963	61	5,773	7,483
Broomcorn	20,317	6,320	3,429	
Dry peas	261	59	1,839	1,834
Sorghums for grain	12,954	19,606	8,150	6,750
Sorghums for silage, hay, and fodder		[1] 12,599	10,304	14,287
All hay	11,799	12,544	[2] 6,299	[2] 8,148
Alfalfa	3,873	5,927	2,715	3,754
Grains cut green	1,066	917	133	1,629
Legumes for hay		167	978	1,270
All other tame hay	1,347	2,089	1,089	1,495
Wild hay	5,513	3,444	1,384	[3]
Blackberries	30	23	159	
Watermelons			112	308

[1] For forage only.
[2] Includes sorghums for hay.
[3] Included with other tame hay.

Cattle rank first among the livestock, both in number and value. There were 44,979 head in the county in 1935. Although most of the cattle are of beef types, about one-half of them are used for dairying. Aside from the many purebred bulls introduced in recent years, only a few cattle are purebred. Hereford and Shorthorn are the principal breeds of beef cattle. Most of the large ranches are in the western part of the county. Dairying and beef production receive little attention on farms having heavy-textured wheat-producing soils. On most of the farms in the sections devoted to diversified systems of agriculture a few dual-purpose cattle are raised. Most of the farmers have cream separators, and dairy products are sold in the nearby towns. In 1929, 9,292 cows were milked, 3,524,763 gallons of milk was produced, and 196,545 gallons of milk and 732,456 pounds of butterfat, valued at $49,136 and $300,307, respectively, were marketed. In 1934, 12,599 cows were milked, and 3,770,716 gallons of milk was produced.

Very few sheep are raised. Goats are raised in the sandy sections, for the purpose of clearing the pastures of brush. In 1935 there were 3,256 sheep and 4,623 goats in the county.

Horses are kept on almost every farm, but very few work animals are raised within the county. The horses are principally of medium-draft type, ranging in weight from 1,000 to 1,600 pounds. The 1935 census reports 7,025 horses and 1,034 mules.

Poultry is raised on most of the farms and constitutes an important source of farm income. In 1929, 1,022,984 dozens of eggs were produced, of which 688,089 dozens, valued at $165,141, were sold. The number of chickens raised was 327,185, valued at $232,301; of these 114,668 were sold alive or dressed. In 1934, 666,275 dozens of eggs were produced and 260,264 chickens were raised. Climatic and range conditions are favorable for raising turkeys. The number raised in 1929 was 16,117, valued at $40,293.

In those parts of the county having soils productive for wheat, the average farm is well improved and well equipped. A large number of grain farmers fence only the part of their land that is utilized for grazing livestock. Ranchers do not attempt to shelter their livestock in sheds but depend largely on wooded and rough broken land for their protection from northers. Most of the cash-grain farms are well equipped with machinery consisting of chisel plows, tractors, combines, plows, and drills. Basin listers, deep-furrow drills, and spring-tooth harrows are becoming more favored because of their aid in the conservation of moisture and in the prevention of soil blowing. There are more wheat headers used in the southwestern part of the county. Much of the grain is hauled to market in trailers. Most of the machinery is left in the open.

Where diversified systems of farming are practiced, the buildings are not so large or so substantial. Tractors are used on some of these farms, but horses are more common.

No systematic methods are practiced for increasing or maintaining the productivity of the soils. Very little commercial fertilizer is used, only eight farms reporting its purchase in 1929 at a total cost of $488. A few farmers use barnyard manure. The growing of soil-building crops, however, is becoming common. Loss of plant nutrients lowers crop yields more rapidly on sandy soils than on the

heavier soils, but yields are increased more readily by soil-improvement crops on the sandy soils.

The purchase of feed was reported by 1,244 farms in 1929, at a total cost of $143,585, or an average of $115.42 a farm reporting. Labor was hired on 1,179 farms for total wages of $196,545, or $166.70 a farm reporting.

Of the 2,093 farms reported by the 1930 census, 510 are classed as general farms, 977 as cash-grain, 113 as self-sufficing, 84 as cotton, 39 as crop-specialty, 23 as fruit, 50 as dairy, 85 as animal-specialty, 3 as truck, 24 as stock ranches, 25 as poultry, and 69 as abnormal, and 91 farms were unclassified. The number of farms increased slightly to 2,131 in 1935, of which 50.4 percent were operated by owners, 49.3 percent by tenants, and 0.3 percent by managers. The average size of farms is 266.7 acres. This comparatively large average results from the inclusion of ranches among the 46 farms that are 1,000 or more acres in size. Land in farms comprises 94.8 percent of the total area of the county.

Land prices have a wide range. The lowest priced land is that which can be used only for grazing purposes, although some of the rough broken land brings a high price because of oil leases. The land suitable for cultivation in the northeastern and central parts of the county has the highest selling price. The value of the land depends largely on the location, the lay of the land, the kind of soil, and the distance to towns. The price of land in the Mennonite settlements is usually higher than elsewhere.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [3] and its content of lime and salts are determined by simple tests.[4] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, especial emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. In places two or more of these principal units may be in such intimate or mixed pattern that they cannot be shown separately on a small-scale map but must be mapped as (4) a

[3] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[4] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

complex. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (5) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Reinach, Pond Creek, and Pratt are names of important soil series in this county, from the point of view of agricultural value.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Reinach very fine sandy loam and Reinach silty clay loam are soil types within the Reinach series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance, the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

Major County lies in northwestern Oklahoma near the eastern edge of the section of pedocalic soils. Here the precipitation is insufficient to keep the soil layers leached of calcium carbonate and, therefore, in normally developed soils this material accumulates in some layer of the soil profile. The mean annual precipitation is about 28 inches, and, because of this rather low rainfall, comparatively little leaching of plant nutrients from the heavier textured soils has taken place.

In the light sandy soils, however, calcium carbonate, as a rule, is leached to a depth ranging from 8 to 10 feet. All the soils that are not severely eroded or that have not been developed from deep sand or recently deposited materials have dark surface soils because of the accumulation of organic matter derived from the decayed grass roots.

The three general broad groups of soils (fig. 2) in this county are: (1) The moderately heavy soils of the smooth higher lying plains in the extreme northeastern and southwestern corners and of the broad lower plain extending as a belt from northwest to southeast through the county; (2) the loose deep sandy soils of the broad belts extending from northwest to southeast across the eastern and southwestern parts; and (3) the rough broken lands of the escarpment and adjacent areas, largely confined to the "Red Beds" area.

For convenience of discussion, the soils are grouped as follows: (1) Soils with friable surface soils and moderately heavy textured subsoils, (2) soils with heavy-textured surface soils and subsoils, (3) soils with sandy surface soils and moderately heavy textured subsoils, (4) soils with sandy surface soils and sandy subsoils, (5) arable soils of the bottom lands, and (6) soils generally unsuited for cultivation.

About 53.4 percent of the county is covered by soils that are generally suited for cultivation, and 46.6 percent is so rough, broken, and eroded or sandy and unstable that it is unsuited for cultivation.

The rough, broken, or eroded lands, for the most part, are developed on the "Red Beds," which consist of fine-grained sandstones, clay, and clay shales. Here, erosion is severe and gullying is common. The soil materials washed from these lands are spread over the lower plain, give rise to deep productive soils, and constitute the soil materials throughout most of the smooth and nearly level areas in the central and northwestern parts of the county. Here, the development and productivity of the soils differ considerably, apparently depending on the length of time the processes of soil development have been in operation on the existing soils. In some places where the material has lain in place for a longer time and where the surface is nearly level, carbonate of lime occurs at greater depths and the surface soils are thicker, more friable, and have a greater accumulation of organic matter than elsewhere. Larger yields of crops are obtained on the more deeply developed soils.

Wide variations in soil characteristics and productivity also exist in the sandy soils. As previously mentioned, carbonate of lime is leached to a depth ranging from 8 to 10 feet in most of the deep loose sandy soils, but it occurs at a slight depth in places along streams and rivers and along slopes between the uplands and alluvial lands. Many of the sandy soils are so loose, porous, and unstable that they are unsuited for the production of crops. The surface soils are light colored and have only a small content of organic matter. Those sandy soils which contain more fine material have a greater accumulation of organic matter and perhaps contain some unweathered feldspar. They retain a larger amount of moisture and of plant nutrients and, therefore, are more productive as compared with the sandier soils.

Approximately 36 percent of the land in this county was in cultivation in 1934. Although the acreage of wheat is greater than the combined acreage of all other crops, a comparatively wide variety of crops is grown. This section is well suited to the production of

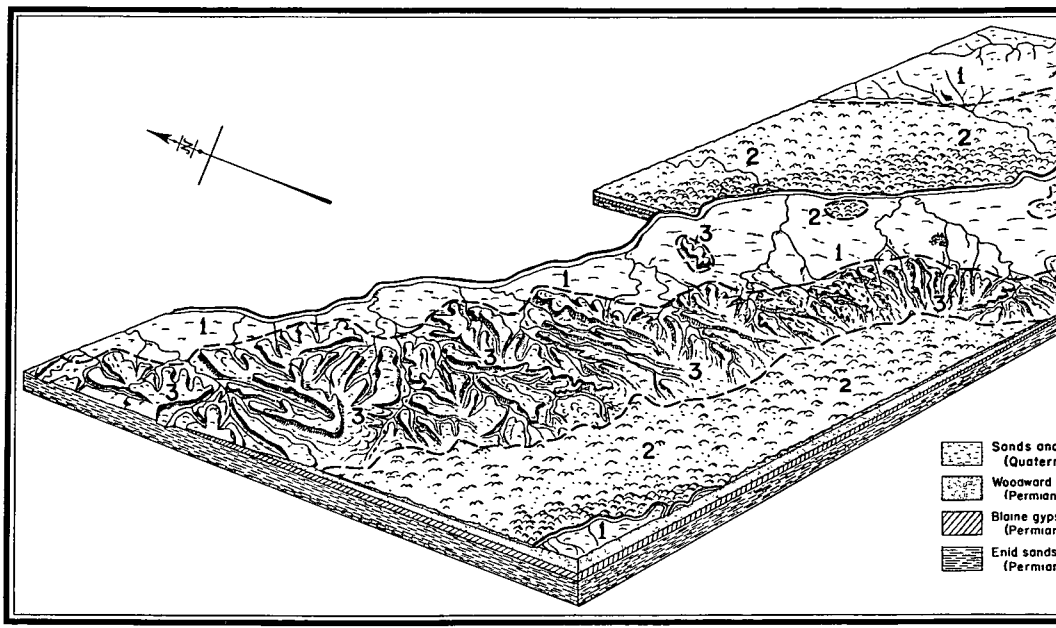


FIGURE 2.—Diagram showing the location of the principal land features of Major County, Okla. soils of the plains and old stream terraces, used mainly for the production of wheat; 2, loose san a wide variety of crops; 3, rough broken land, mostly unsuited for cultivation.

winter wheat, because wheat passes through the winter season in a semidormant stage and is matured by the early summer rains. Aside from its adaptability, wheat can be produced more economically than many of the other crops, because the large smooth areas allow the use of power machinery. Some of the soils are too light and occur in too small and irregular areas for successful production of wheat, although the crop is grown on a wide range of soils. Grain sorghums do well on most of the sandy soils.

The proportionate acreage devoted to the several crops differs somewhat in the different parts of the county. Although wheat is grown on most soils where the relief is suitable for tillage operations, it is grown more extensively than grain sorghums and other feed crops on the heavy-textured soils. As a rule, however, the system of agriculture is more diversified in those sections having sandy soils than in those where the soils are dominantly heavy textured. Wheat, cotton, and, to some extent, grain sorghums are sold as cash crops in the sandier areas, but the agriculture tends to be more self-sufficing. A large proportion of the cultivated land is planted to feed crops—oats, sorghums, sorgo, and some corn—which are consumed on the same farm by livestock. Grain sorghums are grown chiefly on sandy lands. On most of the farms in the western part of the county, where the relief is more rolling and red sandy lands predominate, grain sorghums are the main crop. Most of the corn is grown on sandy and alluvial soils. Medium-textured alluvial soils with moderately well drained subsoils produce most of the alfalfa, especially southeast and northeast of Fairview and in the southwestern and northeastern parts of the county. Provided the subsoil is well moistened by the water table (*1*), alfalfa does well on soils that are too heavy for the other crops common to this general region (*6*). Rye is grown with fair success on a few farms in the southwestern part of the county on some sandy soils.

Most of the fruit is grown on sandy lands. Soils best suited for fruit trees are those with friable clay loam subsoils and porous substrata.[5] Soils having heavy clay or claypanlike subsoils are not suited for fruit trees. Cherries, however, are reported to do well on soils having heavy clay subsoils, provided the surface soil is sufficiently permeable for the penetration of water. Berries, including blackberries, dewberries, and gooseberries, thrive on sandy lands, and a number of patches, 10 acres or more in size, are southeast of Cleo Springs. Berries are better adapted to the very light sandy soils than are most other fruits. Many of the sandy soils are well suited to the growing of grapes, and several small commercial vineyards are in the sandy section (*3*).

Although melons, vegetables, and fruits are grown largely for home use, some of these products are marketed locally. The inherent productivity of most of the light sandy soils is comparatively low, but many farmers prevent severe depletion of fertility by the planting of field peas, beans, and other soil-improvement crops. Peanuts are sometimes grown, and all these crops help to supply feed for

[5] LOCKE, L. F. VARIETIES OF FRUIT AND NUTS FOR THE SOUTHERN GREAT PLAINS. U. S. Bur. Plant Indus., 23 pp., illus. 1932. [Mimeographed.]

livestock. The cash income is not so large on many farms in the sections of sandy soils as in the sections of heavier textured soils, but the operation of the farm usually entails less expense. A few small truck farms and commercial orchards are established on these soils.

Two general sections of smooth or nearly level areas of heavy-textured soils are developed, one in the central and northwestern parts and the other in the northeastern part of the county. Farming in these sections is on a comparatively large scale, and wheat constitutes practically the whole source of farm income. Very little cotton is grown compared with the sandy sections. A small acreage is devoted to feed crops on the heavy soils that do not have favorable moisture conditions during midsummer droughts. Very few livestock are kept, and the work is accomplished by tractor-drawn implements.

Land unsuited for cultivation is used almost exclusively for furnishing pasturage to livestock, mostly cattle. Goats and a few sheep are raised on farms in the sandy sections. Although a few cattle ranches are on the bottom lands and sandy uplands, most of them are situated where the proportion of rough broken land is large. Some of the best pasturage is afforded by the sandy lands that are unsuited for cultivation.

The soils of the bottom lands differ widely, not only in the texture of both surface soil and subsoil, but also in the content of organic matter. Some of these soils are composed almost entirely of loose incoherent sandy material, and others are heavier textured, ranging from fine sand to clay. Their chemical characteristics as well as their physical features have an important bearing on the agricultural value of any particular soil in the bottom lands. Some of these soils have such a high content of soluble salts or are so frequently inundated that they are unsuited for cultivation.

The most serious problems in destructive erosion and rapid run-off are in the western half of the county. Serious damage to soils on cultivated areas is caused by washing of the loose light- or medium-textured surface soils. Erosion has been greatly accelerated by the continuous growth of clean-cultivated crops in many areas along the high divides above the escarpment. Many of the disastrous effects of erosion on areas below the escarpment could be avoided by contour farming and proper cultivation, by proper selection of crops, in a few places by constructing terraces, and by diverting the run-off from the higher adjacent sloping areas. Permanent damage from erosion is taking place rapidly on the heavily grazed pasture land composed of heavy-textured soils, especially during dry years. The thin, friable surface soil is washed away, and the impervious clay or bedrock is exposed.

In the following pages the soils of Major County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Major County, Okla.*

Soil type	Acres	Per-cent	Soil type	Acres	Per-cent
Pond Creek silt loam	9,984	1.6	Reinach loamy fine sand	8,384	1.4
Grant very fine sandy loam	9,728	1.6	Canadian loamy fine sand	1,472	.2
St. Paul very fine sandy loam	3,840	.6	Lincoln loamy very fine sand	3,648	.6
Reinach very fine sandy loam	26,560	4.4	Lincoln silt loam	384	.1
Rusk silt loam	9,984	1.6	Lincoln very fine sand	3,776	.6
Weymouth very fine sandy loam	23,936	3.9	Yahola very fine sandy loam	3,392	.6
Weymouth fine sandy loam	4,160	.7	Yahola fine sandy loam	3,712	.6
Canadian very fine sandy loam	1,024	.2	Yahola clay	17,344	2.8
Rusk very fine sandy loam	4,672	.8	Tivoli fine sand, dune phase	107,136	17.6
Foard very fine sandy loam	1,856	.3	Pratt loamy fine sand, dune phase	25,984	4.3
Nash very fine sandy loam	4,608	.8	Pratt loamy coarse sand	960	.2
Rusk silty clay loam	4,608	.8	Vernon very fine sandy loam, broken phase	6,592	1.1
Fairview silty clay loam	17,024	2.8	Vernon-Fairview complex	19,008	3.1
Fairview silty clay loam, flat phase	4,928	.8	Vernon clay, eroded phase	11,328	1.9
Foard silty clay loam	2,496	.4	Rough broken land (Vernon soil material)	72,320	11.8
Calumet silty clay loam	11,904	2.0	Rough broken land (Quinlan soil material)	25,856	4.1
Reinach silty clay loam	1,472	.2	Carwile clay	1,280	.2
Reinach clay	2,560	.4	Lincoln clay, imperfectly drained phase	1,984	.3
Reinach clay, heavy-subsoil phase	6,912	1.1	Lincoln clay, saline phase	1,152	.2
Pratt fine sandy loam	16,640	2.7	Yahola loamy very fine sand	1,280	.2
Reinach fine sandy loam	12,672	2.1	Riverwash	9,664	1.6
Carwile fine sandy loam	9,280	1.5			
Carmen fine sandy loam	896	.1			
Pratt loamy fine sand	48,704	8.0			
Tivoli fine sand	39,168	6.4			
Enterprise loamy very fine sand	2,432	.4			
St. Paul loamy very fine sand	1,856	.3	Total	610,560	

SOILS WITH FRIABLE SURFACE SOILS AND MODERATELY HEAVY TEXTURED SUBSOILS

All the soils of this group are productive and are especially suited for the production of wheat. The texture, structure, inherent productiveness, and relief of these soils are similar. Their surface soils are friable and moderately heavy, and they grade into crumbly and moderately heavy subsoils. These soils cover an area of 156.8 square miles, or 16.5 percent of the land in the county and 30.8 percent of the land suited for crop production. They comprise many widely separated small and large areas scattered throughout all the smoother sections.

The following 11 soils are included in this group: Pond Creek silt loam, Grant very fine sandy loam, St. Paul very fine sandy loam, Weymouth very fine sandy loam, Weymouth fine sandy loam, Foard very fine sandy loam, Nash very fine sandy loam, Reinach very fine sandy loam, Rusk silt loam, Canadian very fine sandy loam, and Rusk very fine sandy loam. The first 7 soils have developed from very fine sand and clay shale of the "Red Beds" formation, and the others have developed from thick beds of old alluvium consisting of clays, sandy clays, and sands.

Wheat is the principal crop grown on these soils, and grain sorghums, sorgo, cotton, alfalfa, and a few other crops also are grown with success. The friable surface soils and the smooth or nearly level surface allow ready penetration of rain water. The subsoils retain a large reserve of soil moisture to be drawn on in dry seasons or periods of drought. Summer rains aid the crops on these soils less than on the lighter sandy soils, which absorb water more readily. Grain sorghums and related crops withstand midsummer droughts on these soils better than do corn and alfalfa.

Pond Creek silt loam.—Pond Creek silt loam is characterized by a dark-colored heavy but crumbly subsoil without free calcium car-

bonate (lime). It is developed at the western edge of the zone of pedalferic soils from the partly weathered very fine sand and clay shale materials of the "Red Beds." The surface soil, to a depth of 12 inches, is brown or dark-brown granular soft friable silt loam well supplied with organic matter. The lower part of this layer is slightly heavier than the upper part. It is underlain, to a depth of 22 inches, by dark reddish-brown or brownish-red friable granular silty clay loam, and this grades into red silty clay loam or heavy silty clay loam. Below a depth of about 3 feet this material rests on dark reddish-brown heavy clay, which breaks into approximate 1-inch cubes. Below a depth of about 5 feet the material consists of friable red clay or very fine sandy clay.

The friable and granular character of the upper soil layers allows easy penetration of water and plant roots. Consequently, the tilth is good, and a good seedbed for wheat and other crops is easily prepared. The upper part of the subsoil is sufficiently friable to allow easy penetration of water. The material of the subsoil, especially that in the lower part, has a large water-holding capacity, which aids crops to withstand long periods of drought.

This soil occupies rather large areas in the northeastern part of the county. Approximately 40 percent of the plain lying east of Indian Creek and north of the sandy-land belt south of Meno is covered by this soil. The surface is very nearly level, and, although surface drainage is slow, it is sufficient to allow all surplus water to be removed after heavy rainfalls. Slow run-off, which allows the storage of soil moisture, and high inherent fertility are factors contributing to the high productivity of this soil.

The principal variation occurring within areas of this soil consists of comparatively friable red clay in the lower part of the subsoil as well as in the upper part, but the total area covered by soil having such variation is not large. Also included in mapping are small bodies having a shallow heavy clay subsoil. The soil in these small areas resembles Foard silty clay loam with a microrelief of slight depressions.

Practically all of this land is in farms, and probably not less than 90 percent is cultivated. Approximately 80 percent is cropped to wheat, 10 percent to row crops (corn, grain sorghums, and sorgo), 5 percent to alfalfa, and 5 percent is in native pasture. This soil is suited to the production of both wheat and row crops, but at present it is more commonly used for the production of wheat because yields of wheat are comparatively large and the soil occurs in large smooth areas, on which improved machinery can be operated easily. During normal seasons wheat yields about 20 bushels, corn 15 to 25 bushels, grain sorghums 15 to 25 bushels, and alfalfa 1 to 2 tons an acre.

The production of fruit on a commercial basis has been tried, but cherries only have proved successful. There are a few home orchards and gardens, most of which are irrigated with water obtained by windmill pumps.

The grazing afforded by the native pasture on this soil is considered about the best in the county. Although the land generally is considered too valuable for crop production to be left in native pasture, small plots are kept in grass for pasture on a few farms. The pastures

are covered by a thick stand of short grasses, principally buffalo grass and blue grama.

Grant very fine sandy loam.—The surface soil of Grant very fine sandy loam consists of brown or reddish-brown very fine sandy loam, to a depth of about 6 inches, grading into red or reddish-brown heavy granular silt loam. This gives way, at a depth of about 14 inches, to brownish-red friable silty clay loam, which is granular and very permeable. Below a depth of about 28 inches, this material gradually passes into red friable very fine sandy loam, which contains very few subangular and rounded structural particles. About 65 inches below the surface, this material is underlain by slightly weathered calcareous very fine sandy loam of the "Red Beds" formation. The subsoil contains a large quantity of very fine sand and, in places, some fine sand and coarse sand. In a few areas the subsoil is similar to that of Pond Creek silt loam, but the surface soil is reddish brown. The reddish-brown surface soil is distinguished readily in cultivated fields.

This soil is developed in the northeastern part of the county in association with Pond Creek silt loam, which is a normally developed pedalferic soil. Calcium carbonate is absent above a depth of about 65 inches. Although the surface soil does not contain a large quantity of organic matter, it does not have an accumulation of calcium carbonate in the subsoil as do most soils farther west.

This is not an extensive soil, but several fair-sized areas are east of Meno. Although the surface is gently rolling or rolling, the porous subsoil is so permeable that surface drainage is not excessive, and much of the rain water is absorbed.

Probably 85 percent of this soil is in cultivation and is used mainly for the production of wheat. About 12 percent of the cultivated land is used for the production of corn and grain sorghums, and 3 percent for alfalfa and other miscellaneous crops. It is reported that in years of average weather conditions, wheat yields about 16 bushels an acre, grain sorghums 20 bushels, and corn 18 bushels. Probably this soil is as well suited to the production of corn and grain sorghums as is Pond Creek silt loam. Many small and irregular bodies are farmed in conjunction with the Pond Creek soil.

A few home orchards and gardens produce moderate quantities of fruits and vegetables for home use. The native grasses, mainly grama and buffalo grass, provide good pasturage for the farm livestock.

St. Paul very fine sandy loam.—St. Paul very fine sandy loam has one of the most friable and permeable subsoils of any soil in this group. The surface soil consists of reddish-brown or dark reddish-brown very fine sandy loam to a depth of about 8 inches. This passes gradually into slightly heavier and darker reddish-brown friable very fine sandy loam, which has a mellow mealy structure. Below a depth of about 14 inches this material grades into reddish-brown heavier very fine sandy loam, which, below a depth of about 24 inches, gradually gives way to brownish-red friable granular very permeable silty clay loam. A large proportion of this material is very fine sand and silt, and, in places, even the deep material is very fine sandy loam.

St. Paul very fine sandy loam as mapped in this county is slightly redder than that mapped in most areas.

According to field tests, the surface soil and subsoil are free of calcium carbonate, although doubtless the material is basic or neutral

in reaction. Below a depth of about 40 inches, especially in places where the heavier texture of the subsoil prevails, an accumulation of calcium carbonate is indicated by the presence of a few hard and some soft concretions of this material.

In some places, where the lower part of the subsoil is very light textured, lime is not present. Although this soil is a normally developed Pedocal, the layer of calcium carbonate accumulation is not so well defined here as in larger smoother areas farther west. In this county, the subsoil material, below a depth of 40 inches, is light-red loamy very fine sand, and this passes, at a depth ranging from 4 to 5 feet, into unweathered Red Beds of very fine sand and shale materials.

St. Paul very fine sandy loam is of slight extent in this county. A few small areas are in the western part in the vicinities of Phroso and Sherman. The surface is smoothly undulating, the slopes are so gentle, and the subsoil is so permeable that most of the rain water is collected and absorbed with but very slight loss through run-off. The same features of relief prevent serious washing of the soil except on the steeper slopes where the surface is not protected.

This soil is considered highly desirable farm land, because it is easily tilled, conserves moisture well, and is moderately productive. Probably 90 percent of it is in cultivation. In the unprotected fields, the soil, when dry, has a tendency to drift and blow during heavy spring winds.

St. Paul very fine sandy loam is about as productive for wheat as any soil in this group, although yields may average slightly less because the soil lies in the extreme western part of the county where the average annual rainfall is about 4 inches less than in the eastern part. Although this soil is well suited to the production of most of the other crops commonly grown in the general region, it is used almost entirely for wheat. According to local farmers, it yields an average of about 15 bushels of wheat and from 18 to 24 bushels of grain sorghums an acre in favorable seasons. In dry seasons the soil sustains crops well, because of the favorable physical characteristics and soil moisture conditions, and crop failures due to drought are rare. Grain sorghums and sorgo grow well and produce good yields of forage, the amount depending on moisture conditions. Small grains other than wheat do well.

Reinach very fine sandy loam.—The surface soil of Reinach very fine sandy loam is dark-brown or dark reddish-brown friable very fine sandy loam to a depth of about 8 inches, where it grades into dark-brown friable heavy very fine sandy loam, which, below a depth of about 16 inches, passes into dark reddish-brown light-textured crumbly silty clay loam. Below a depth of 32 inches, the subsoil, in most places, consists of interbedded layers of red or brownish-red loamy fine sand and very fine sandy loam, or even heavier material. The lower part of the subsoil is calcareous in many places at an average depth of about 34 inches. In places, a few concretions of calcium carbonate are present in the lower subsoil layer, but such segregated concretions are, as a rule, few and indistinct. Beds of water-worn coarse sand and fine gravel lie, in places, at a depth of several feet below the surface.

This soil covers a larger total area than any other member of this group and is most extensively developed in the central and north-

western parts of the county. Most of the small areas are in shallow valleys along small streams and drainageways and are usually slightly above overflow. The surface is very nearly level or gently undulating. Drainage almost everywhere is slow, and much of the rain water is held by the soil.

Three principal variations of Reinach very fine sandy loam may be noted, which, in places, constitute transitions of typical areas into certain other soils: (1) In narrow strips along drainageways on the low flat plain in the vicinity of Fairview, the soil, in places, is rather red and is calcareous; (2) in the northwestern part of the county and on the lower plain around Fairview, the surface soil is darker than normal in many of the larger areas; and (3) adjacent to areas of Calumet and Rusk soils the subsoil is, in some places, rather heavy and contains little or no interbedded sandy material. Areas of this soil, however, are distinguished readily from the Calumet and Rusk soils because of the more generally friable and more sandy character of the subsoil. This soil is developed from old alluvium on terraces that lie high above overflow.

Good pasturage is provided for livestock by the native grasses, mainly a moderately thick growth of buffalo grass and some of the grama grasses.

The farmers consider this to be very good crop-producing soil, and probably 90 percent of it is under cultivation. Although wheat is the principal crop grown, cotton, grain sorghums, oats, sorgo, Sudan grass, and alfalfa are important. According to information obtained from farmers, this soil, in normal seasons, yields about 16 bushels of wheat to the acre, one-fourth to one-half bale of cotton, 20 to 30 bushels of grain sorghums, and 20 to 30 bushels of oats. Sorgo and Sudan grass produce from 2 to 3 tons of coarse forage, and alfalfa 1 to 3 tons of hay.

A large part of the land has been cropped continuously to wheat for many years. In many of the smaller areas adjacent to streams and in places where the subsoil is more friable, grain sorghums and forage crops are more commonly grown. Most of the alfalfa grown on this soil is on areas in the vicinity of Fairview, on smooth areas near the Cimarron River and Deep Creek, and in the northeastern part of the county. Very little corn is grown. Cotton is grown mostly on small areas in the central part. Crops, especially small grains and cotton, withstand droughts well. The character of the relief and the permeability of the soil prevent excessive run-off.

Rusk silt loam.—Rusk silt loam is characterized by a dark-brown or dark reddish-brown silt loam surface soil and a reddish-brown or red heavier subsoil. The 6-inch surface layer is dark-brown or dark reddish-brown friable silt loam, which grades into an 18-inch layer of dark reddish-brown silty clay loam, which is comparatively friable and allows ready penetration of roots. Below a depth of 24 inches is dark reddish-brown or dark-red heavy clay. This passes gradually, at a depth of about 3 feet, into light-red friable highly calcareous silty clay loam containing numerous soft aggregates and splotches of calcium carbonate. Below a depth of 70 inches the material consists of layers of soft friable silty clay loam and very fine sandy loam.

The largest areas occupy the low level plain in the vicinity of Fairview. The surface generally is more nearly level than that of

the surrounding soil areas, and run-off is a little slower. The general slope, however, is sufficient to afford adequate surface drainage.

The friable surface soil and upper subsoil layer, the large water-holding capacity of the subsoil, and the uniform relief are important features in making this soil suited for the production of wheat. Approximately 90 percent of the land is tilled. About 80 percent of this is used for the production of wheat, 8 percent for cotton, 5 percent for grain sorghums, sorgo, and Sudan grass, and 7 percent for pasture.

This soil is best suited for the production of small grains, although cotton does well. In years of average weather conditions, wheat yields about 16 bushels an acre, alfalfa 1 to 2 tons, oats 25 to 30 bushels, grain sorghums 20 to 25 bushels, and cotton one-fourth to one-half bale. The yield of alfalfa is not so high for a few years after seeding as on some of the lighter soils. The stand thins out less, however, and produces over a longer period than on those soils.

With sufficient rainfall crop yields are good, but in dry seasons yields of grain sorghums, sorgo, alfalfa, and cotton are greatly lowered, as these crops do not withstand drought well unless a very good supply of moisture has been stored before the growing season. A few small orchards and home gardens are maintained on some farms. Although peach, pear, plum, and shade trees will grow if careful attention is given them, cherry trees grow more successfully.

The luxuriant native grasses are predominantly buffalo grass and blue grama.

Weymouth very fine sandy loam.—The 12-inch surface soil of Weymouth very fine sandy loam consists of reddish-brown very fine sandy loam. It grades into a reddish-brown permeable and somewhat granular heavy clay loam or clay subsoil. This, in turn, grades, at a depth of about 22 inches, into calcareous red clay or clay loam, containing numerous concretions of calcium carbonate. At a depth ranging from 30 to 40 inches this rests on "Red Beds" material consisting of red, gray, and blue clay shale, which contains some thin layers of calcium carbonate and gypsum.

On the soil map small spots of Vernon very fine sandy loam are included, in which the parent material is close to the surface. In many places where the soil is shallow, concretions of calcium carbonate are present in the surface soil. In some freshly tilled dry fields, small spots of dark grayish-brown soil, associated with beds of gypsum containing dolomitic limestone, are present. These spots are too small and intricately associated with the typical soil to be mapped separately. Another variation consists of small spots having a more deeply developed subsoil and a darker surface soil.

Weymouth very fine sandy loam covers a large total area. It occurs only on the upper plain in the western and south-central parts of the county, where the land is gently rolling. Bodies of this soil range in size from 400 acres to ones too small to be shown separately on the map. The Weymouth soils are developed in close association with the Vernon soils from calcareous moderately heavy shale or sandy clay materials of the "Red Beds" formation. They resemble the Vernon soils but are more advanced in development, although they are immature and lack the deep normal development of such soils as St. Paul very fine sandy loam.

Probably 85 percent of the land is cultivated, and approximately 70 percent of the tilled land is used for the production of wheat, 20 percent for feed crops, such as grain sorghums, sorgo, and corn, and 10 percent for cotton and miscellaneous crops. Many areas are too small and too irregular in shape for the profitable use of large machinery. Most of these small areas have a slope ranging from 2 to 3 percent, and in places they are bordered by strips of rough broken land. In these areas erosion is more active than in the larger areas. The unprotected soil in cultivation is subject to rapid erosion (pl. 1, *A*).

In years of average moisture conditions, acre yields of wheat range from 10 to 15 bushels, with an average of about 11 bushels; grain sorghums, 15 to 25 bushels; sorgo, 2 to 3 tons of forage; and cotton, one-fourth to one-half bale. As on many other soils of the county, the yields depend largely on the amount and distribution of rainfall. Thus, if a large amount of precipitation falls in gentle rains during fall and spring, the ground is much better supplied with moisture than if an equal amount falls in sudden rains. The slightly sloping surface and the clay loam subsoil prohibit the rapid penetration of water. Only a few trees can withstand the droughty conditions, and only a few small orchards and home gardens are maintained. Cherry trees are said to endure drought better than other fruit trees. Well water is not everywhere available.

Weymouth fine sandy loam.—Weymouth fine sandy loam is similar to Weymouth very fine sandy loam, but the surface soil is coarser in texture and consists of reddish-brown fine sandy loam about 10 inches thick. The proportion of very fine sand is comparatively high in the lower part of the layer. This material grades into reddish-brown or brownish-red friable heavy very fine sandy loam, which, at a depth of 26 inches, passes gradually into red permeable clay loam. This layer, in turn, rests on shales and clays of the "Red Beds" formation. This soil generally does not have the well-developed layer of calcium carbonate accumulation in the lower part of the subsoil, which is characteristic of Weymouth very fine sandy loam. In some places, however, where the areas are more rolling and the subsoil is heavier, the accumulation of calcium carbonate is equally distinct.

This is not an extensive soil. The very gently sloping areas occur only on the upper plain west of Fairview, and most of them are closely associated with areas of Pratt and other sandy soils. Small areas are associated with Weymouth very fine sandy loam in the western part of the county. The soil has developed from calcareous "Red Beds" of moderately heavy shale in areas adjacent to soils developed from Tertiary or Quaternary sand and "Red Beds" of sandy material.

This soil is used for practically the same purposes as is Weymouth very fine sandy loam, although a larger proportion is devoted to the production of grain sorghums and sorgo. Yields on these two soils are approximately the same, except that row crops are damaged less frequently on the fine sandy loam by dry hot winds during droughty seasons.

The native vegetation includes bunchgrasses, which generally do not grow on Weymouth very fine sandy loam. Short grasses, which predominate, are abundant.

Canadian very fine sandy loam.—The 6-inch surface layer of Canadian very fine sandy loam consists of brown or dark-brown very fine sandy loam. This grades into dark-brown loose friable silt loam, which, below a depth of 14 inches, passes gradually into dark reddish-brown friable heavy silt loam. Below a depth of 24 inches the subsoil material is friable permeable heavy very fine sandy loam. The color of the subsoil in most places is reddish yellow, although in a large area in the extreme southwestern part of the county it is brownish red. Calcium carbonate, in the form of numerous hard and soft concretions, generally is present below a depth of about 40 inches.

The concretions are absent at a depth of about 52 inches, where the material consists of calcareous reddish-yellow soft friable very fine sandy loam.

This is an inextensive soil, all of which, except two small bodies in the vicinity of Cleo Springs, is in the extreme southwestern part of the county. It occupies flat terraces lying from 6 to 12 feet above the adjoining bottom land. Surface drainage is adequate to remove all surplus water, and underdrainage is free.

This soil is considered well suited for all the common farm crops. Perhaps it is better suited for a larger number of crops than any other soil in this group. Probably more than 95 percent of this soil is in cultivation, and more than 60 percent is used for the production of wheat. Grain sorghums produce well even in years of comparatively low rainfall. In years of average weather conditions wheat yields about 18 bushels an acre, oats about 25 bushels, grain sorghums 26 bushels, sorgo about 2 tons of coarse forage, cotton about one-third bale, and alfalfa 1 to 3 tons. This soil is well suited for fruits and vegetables, which are grown mainly for home use. Watermelons and cantaloups do well and are sometimes grown for the market.

Rusk very fine sandy loam.—The 8-inch surface layer of Rusk very fine sandy loam (pl. 1, *B*) consists of medium-brown, dark-brown, or reddish-brown friable rather loose very fine sandy loam well supplied with organic matter. When dry, it separates into small rounded granules that give it a mealy consistence. It grades into reddish-brown heavy clay loam, which, at a depth of about 18 inches, passes into red or reddish-brown heavy clay that is calcareous in places. The lower part of the subsoil, below a depth of 40 inches, consists of red heavy calcareous crumbly fine sandy clay, which is very plastic when wet and very hard when dry, breaking naturally into small cubical blocks. Calcium carbonate, chiefly in the form of concretions and splotches, is abundant below a depth of 22 inches, but it assumes the form of finely disseminated particles at a depth of about 36 inches. Below a depth of 22 inches the material is slightly lighter in texture than that in the upper part of the subsoil. The red clay continues to a depth of 50 inches, where it is underlain by layers of sand and sandy clay.

Rusk very fine sandy loam is developed in the northwestern part of the county, in the vicinity and west of Cheyenne Valley School. Areas of this soil occupy terracelike positions from 20 to 50 feet above the adjoining bottom lands. The surface is smooth and has a very gentle slope toward the Cimarron River. Despite the heavy clay subsoil, run-off is not excessive, owing to the permeable character of the surface soil and the nearly level surface.

Rusk very fine sandy loam covers a small total area. Several bodies, surrounded by rough broken land (Vernon soil material) and too small to map separately, are included with areas mapped as rough broken land. Small areas of Rusk fine sandy loam also are included.

This soil is rather uniform. In a few places, however, the red heavy clay subsoil lies at a depth of less than 15 inches below the surface, and the color of the surface soil is redder than typical. Such included areas resemble Fairview silty clay loam, but they are too small and irregular to be mapped separately.

Rusk very fine sandy loam resembles Rusk silty clay loam in subsoil characteristics, and it has much the same origin, that is, it is developed from local alluvium washed from adjacent hills of the "Red Beds" formations. The characteristics of the surface soils of these two soils differ considerably.

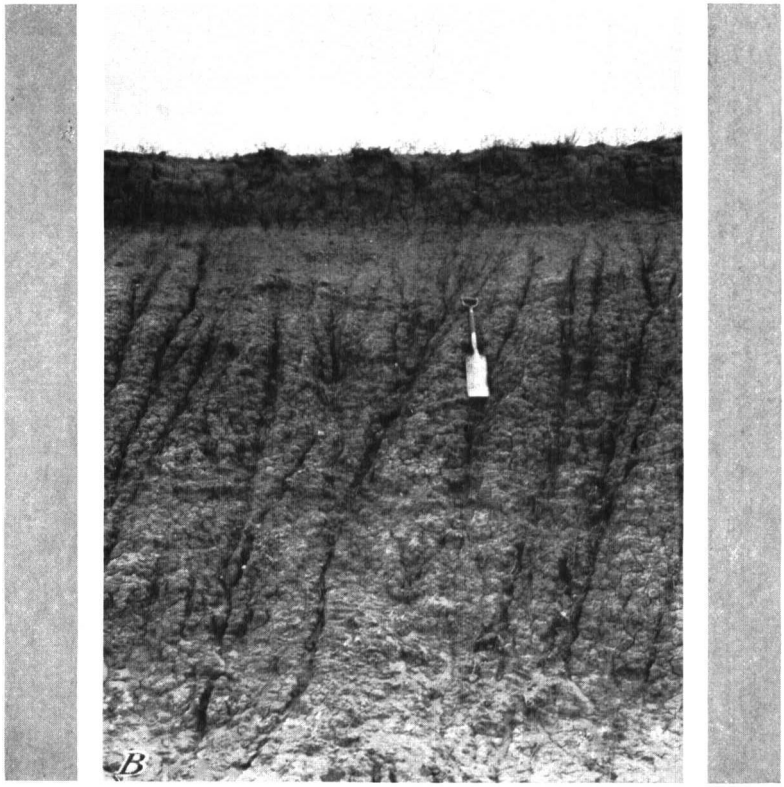
Approximately 90 percent of the land is in cultivation and is devoted almost wholly to the production of wheat. Grain sorghums are grown to a very small extent. Sorgo and Sudan grass are grown to a slightly greater extent. In normal years acre yields of wheat are about 14 bushels, grain sorghums about 18 bushels, and Sudan grass 2 to 3 tons of coarse forage. There are a few home gardens on this soil, and vegetables seem to grow well when the moisture supply is adequate.

The native vegetation consists of buffalo grass and blue grama, together with a scattered growth of low mesquite brush.

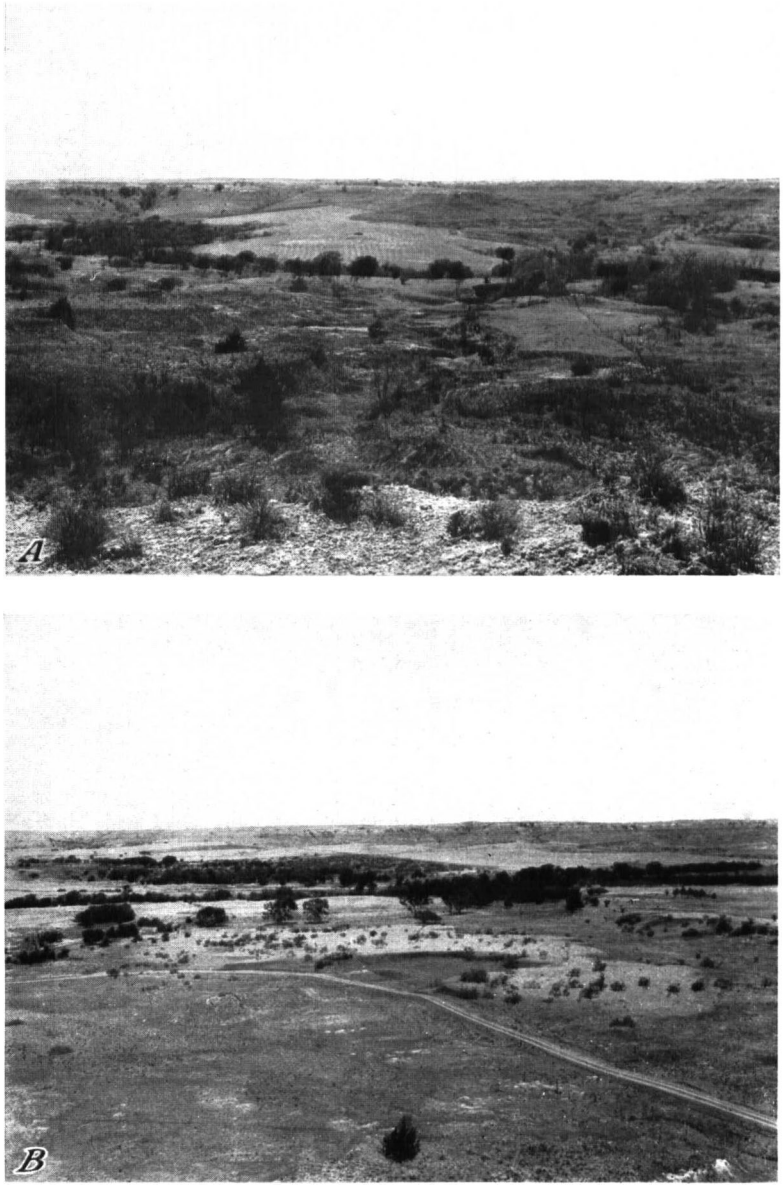
Foard very fine sandy loam.—The 6- or 8-inch surface layer of Foard very fine sandy loam is grayish-brown or dark-brown friable very fine sandy loam. It grades into dark-brown friable very fine sandy loam. Below a depth of about 14 inches this friable material grades into dark-brown permeable clay loam, which, below a depth of about 20 inches, gives way to the subsoil of dense heavy clay that ranges in color from dark brown to reddish brown. At a depth of 34 inches this material grades into reddish-brown calcareous clay, which continues to a depth of more than 45 inches. The lower part of the subsoil commonly is calcareous and contains concretions of calcium carbonate. Below a depth of about 4 feet the material is yellow calcareous clay.

Foard very fine sandy loam occurs in a few rather large areas in the northeastern part of the county near Meno and in a few areas southeast of Fairview. The surface is very nearly level. Drainage everywhere is slow. Although the dense subsoil retards the penetration of rain water to some extent, the surface soil is sufficiently smooth, deep, and pervious that most of the water sinks into the surface soil and subsoil.

This is an inextensive soil. Probably about 90 percent of it is in cultivation, and the rest, which is utilized as pasture land, is covered with native grasses consisting principally of buffalo and grama grasses. Approximately 85 percent of the cultivated land is planted to wheat, 10 percent to row crops (including grain sorghums, sorgo, corn, and cotton), and 5 percent to oats and miscellaneous crops. Probably because of the light-textured surface soil, less alfalfa is grown on this soil than on Foard silty clay loam. The general farm crops commonly grown produce better and more uniform yields than



A, Gullies on steep unprotected slopes of Weymouth very fine sandy loam. *B*, Soil profile of Rusk very fine sandy loam. Although developed in a pedocalic region, the layer of calcium carbonate is not so thick as in some other soils.



A, Fairview silty clay loam on the smoother surfaces, developed from outwashed "Red Beds" material. *B*, View across Cheyenne Valley, showing Yahola clay in the middleground, soils of the Vernon-Fairview complex in the foreground, and an escarpment of rough broken land in the background.

on Foard silty clay loam, as a rule. In years of normal moisture conditions, average acre yields of wheat are 17 bushels, grain sorghums 20 to 25 bushels, corn about 17 bushels, cotton one-third bale, and alfalfa 2 to 3 tons.

Nash very fine sandy loam.—The 8-inch surface layer of Nash very fine sandy loam is reddish-brown or brownish-red friable calcareous very fine sandy loam. It grades into red or brownish-red friable very fine sandy loam or sandy clay loam, which also is calcareous. The upper part of this layer has a slightly lighter color or is brownish red. At a depth ranging from 18 to 24 inches, the material passes into unweathered "Red Beds" of very fine sand, clay, or sandy shale. This material contains calcium carbonate, and in most places the consistence is comparatively loose.

Nash very fine sandy loam is somewhat similar to Weymouth very fine sandy loam. Although these soils have developed from similar calcareous "Red Beds" of comparatively coarse textured shales, they differ somewhat in content of calcium carbonate both in the surface soil and the subsoil. Calcium carbonate is, in most places, absent in the surface soil of Nash very fine sandy loam, and the subsoil, in most places, is calcareous below a depth of 18 inches. In places, however, calcium carbonate concretions are brought to the surface during cultivation.

Mapped areas of this soil include narrow strips, along areas of rough broken land, that have subsoils containing an abundance of calcium carbonate concretions. The concretions occur below a depth of about 24 inches and give an appearance of a well-defined layer of accumulated calcium carbonate, that is so well developed in some of the smoother areas in the western part of the county.

This is not an extensive soil. It all occupies gently rolling areas in the northeastern part of the county, principally north of Ringwood. Although surface drainage is rapid, wastage of the surface soil through erosion is not excessive and can be avoided by proper cultivation. Approximately 90 percent of the soil is in cultivation. About 85 percent of the cultivated land is planted to wheat, although this soil is probably as well suited to the production of row crops, including grain sorghums, sorgo, and corn. In normal seasons acre yields of wheat are about 12 bushels, sorgo 1 to 2 tons of coarse forage, grain sorghums 15 to 20 bushels, oats about 20 bushels, and Sudan grass 1 to 2 tons of hay.

The Nash soils are comparatively youthful and represent a stage of development somewhat more advanced than the Vernon soils, but typically they are confined to the pedalferic zone, where there is no layer of calcium carbonate accumulation in the soil profile. The Nash soils also may be said to represent a youthful stage of development on soil materials, which eventually would produce the Grant soils.

Most of this soil occurs in comparatively small bodies that are farmed in conjunction with the associated soils. This soil is probably better suited for sorghums, but it is used principally for the production of wheat because of its close association with the heavier soils. Most areas of Nash very fine sandy loam are so friable that the soil may be tilled easily and kept in a good loose condition in cultivated fields. Crops withstand dry conditions somewhat better

than on the Pond Creek and Foard soils, but during the years of more favorable weather conditions, yields are considerably lower than on the deeper soils.

Uncultivated areas of this soil are used for pasture. The pastures support a heavy covering of short grasses, mainly blue grama, buffalo grass, and some needlegrass. In places where the land has not been heavily pastured, little bluestem is abundant.

Few home orchards and gardens are on this soil. It is reported that fruits (particularly cherries) and vegetables yield well compared with those on associated soils.

SOILS WITH HEAVY-TEXTURED SURFACE SOILS AND SUBSOILS

The soils of this group have, in general, very heavy textured surface soils, which are low in organic matter and are underlain by very heavy clay subsoils. They occur in small- and medium-sized rather smooth areas and cover a total area of 81.1 square miles, or 8.5 percent of the county. The large smooth plain in the central and northwestern parts is occupied largely by these soils. This group includes Rusk silty clay loam; Fairview silty clay loam; Fairview silty clay loam, flat phase; Foard silty clay loam; Calumet silty clay loam; Reinach silty clay loam; Reinach clay; and Reinach clay, heavy-subsoil phase.

Most of these soils are fairly good for the production of wheat. In general, the land is nearly level, and much rain water is lost by run-off. The surface soils and subsoils absorb moisture very slowly and deliver it very slowly to growing plants. Grain sorphums and related crops are less suited to these heavy soils than is wheat. Although cotton withstands droughty conditions fairly well, yields of this crop, as well as those of grain sorghums, are lowered because most of the growth normally takes place during the driest part of the growing season when the supply of soil moisture either is exhausted or is available too slowly to prevent damage during a drought. Difficulty often is experienced in obtaining a stand of grain sorghums, owing to dry weather in early spring.

Rusk silty clay loam.—The surface soil of Rusk silty clay loam, to a depth of about 8 inches, consists of friable dark-brown silty clay loam, in places having a 2- or 3-inch surface covering of silt loam or very fine sandy loam. This material grades into dark-brown crumbly silty clay or clay, which on drying separates readily into 1-inch cubical particles. Below a depth of about 16 inches, this material passes gradually into more friable red silty clay loam or clay, which, below a depth ranging from 30 to 40 inches, is calcareous and contains an abundance of calcium carbonate concretions. The content of calcium carbonate decreases below a depth of about 40 inches, and the material is underlain by unweathered "Red Beds" clay and clay shale.

Although the subsoil of Rusk silty clay loam consists of heavy clay, it is not so tough and heavy as the subsoil of the Calumet or Foard soils. The material in the layer above the calcium carbonate layer is, in most places, very slightly heavier than that below or above. According to field tests, neither the surface soil nor the upper part of the subsoil, above the calcium carbonate layer, contains calcium carbonate. The depth to calcium carbonate varies somewhat.

Small areas of Rusk silty clay loam are scattered throughout the central and, to less extent, the northwestern part of the county. The relief is slightly rolling, and drainage is fairly rapid although nowhere excessive. In most areas "Red Beds" material of clay and shaly clay occurs at a depth of about 70 inches. In many places the subsoil just above the "Red Beds" material contains comparatively thin layers of clay and slightly lighter textured materials.

This soil covers a total area of 7.2 square miles. Approximately 75 percent of the land is used for the production of wheat; 12 percent for grain sorghums, sorgo, and Sudan grass; 5 percent for cotton; and 7 percent for native pasture. The heavy texture of the surface soil and the subsoil renders this soil well suited for the production of wheat and other small grains. In years of average moisture conditions, wheat yields about 14 bushels to the acre, grain sorghums 15 to 24 bushels, sorgo 1 to 2 tons of coarse forage, and cotton one-third to one-half bale. In years of maximum rainfall the yields may not greatly exceed those on the Fairview soils, but they are not quite so variable. Fruit trees apparently do not grow well on this soil, and very few gardens and orchards are on it. The native grasses consist largely of buffalo grass and blue grama.

Fairview silty clay loam.—Fairview silty clay loam is a heavy soil occurring on the lower plain in areas of moderately sloping relief. The surface soil consists of medium-brown, dark-brown, or reddish-brown silty clay loam from 6 to 10 inches thick. The fine earth in this layer does not effervesce with hydrochloric acid. This material grades into reddish-brown heavy calcareous clay containing in places a few concretions of calcium carbonate. At a depth of about 18 inches the material grades into red heavy clay which, in a few places, also contains concretions of calcium carbonate. Although the clay is heavy, it is not a claypan. The material has very little developed structure and separates into fine sharp subangular particles. It gradually becomes lighter in color and more friable with depth. In most areas clay and shaly clay of the "Red Beds" formation lie from 40 to 50 inches below the surface.

Areas of this soil are undulating, and the slopes are gentle or moderate. Fairly large areas are on the lower plain in the northwestern and central parts of the county, adjacent to the escarpment and areas of rough broken land (Vernon soil material) (pl. 2, *A*). Most of these areas are higher than the adjacent eroded land, but many areas are lower and receive wash from steeply sloping land. Run-off is comparatively rapid but does not cause serious loss of the surface soil, except on the steeper unprotected slopes. The soil is developed from clays and other weathered materials of shales and clays of the "Red Beds," that have been spread by local surface wash over the lower lying plain.

Approximately 75 percent of the land is used for the production of wheat, 15 percent for grain sorghums, cotton, sorgo, and corn, and 10 percent for native pasture. The heavy surface soil and subsoil render this soil well suited to the production of wheat. Although many areas are sufficiently large for the efficient use of large power machinery employed in the production of wheat, a large number of areas are too small and are used for growing grain sorghums or for pasture.

The average yield of wheat is about 10 bushels to the acre. Grain

sorghums yield 10 to 15 bushels, cotton one-eighth to one-third bale, and sorgo 1 ton of forage. Crop yields are somewhat more variable than those on many other soils. They depend on the degree of slope, the rapidity of run-off, and the amount of erosion that has taken place. The sloping surface and the slow absorption of water by the subsoil retard the conservation of moisture and favor erosion. Only a few home gardens and orchards are on this soil. Fruit trees do not grow very well, but some vegetables produce moderate yields when soil moisture is adequate.

Fairview silty clay loam, flat phase.—Fairview silty clay loam, flat phase, differs from Fairview silty clay loam in that it is almost level instead of undulating, but other characteristics are similar in the two soils. The surface soil of Fairview silty clay loam, flat phase, is dark reddish-brown silty clay loam about 6 inches thick. This grades into dark-red clay, which, in places, is calcareous. No granulation is developed in the clay subsoil, and the material, when dry, separates into sharp fine fragments. It rests on red shale of the "Red Beds" formation, at a depth ranging from 30 to 60 inches.

This soil covers a much smaller area than the typical soil. The areas occupy terracelike positions in the central and northwestern parts of the county. Because the land is smooth and flat, surface drainage is slow, and rain water, in places, flows over the surface from higher adjacent lands. Rain water is absorbed very slowly because of the heavy texture of the soil material. In many places the surface soil is slightly heavier than that of the typical soil and tends to pack tightly on drying. Following heavy rains it is not uncommon for the surface to crust in such a way as to retard the development of sprouting plants, sometimes causing poor stands. In places the surface soil is calcareous.

This soil is suited to the same crops as the typical soil, but yields are somewhat more variable, depending on moisture conditions. Approximately 75 percent of the land is in cultivation. Probably not less than 90 percent of the cultivated land is planted to wheat, and 10 percent is planted to grain sorghums, sorgo, cotton, and a few other crops. In years of average moisture conditions wheat yields about 9 bushels an acre, grain sorghums 10 to 15 bushels, sorgo about 1½ tons of rough forage, and cotton not more than one-fourth bale.

Native pasture is, in general, of high value because of the heavy covering of short grasses. Buffalo grass and blue grama predominate, and in places some side-oats grama and three-awn grasses grow.

Foard silty clay loam.—The surface soil of Foard silty clay loam, to a depth of 8 inches, consists of dark grayish-brown or dark-gray silty clay loam, which, when moist, is dark and crumbly but on drying packs tightly. This rests on dark-gray or dark grayish-brown very tough clay which, below a depth ranging from 24 to 30 inches, grades into brown or reddish-brown clay that is slightly less dense than the material in the layer above. Below a depth of about 3 feet this gives way to yellowish-brown and gray mottled clay loam containing an abundance of calcium carbonate in concretions and in disseminated form. At a depth ranging from 5 to 6 feet this material grades into unweathered "Red Beds" clay shale.

Although the surface soil is rather heavy, it can be worked readily when the moisture content is favorable, and fairly good tilth is ob-

tained in most places. In a few small areas, most of them south of Meno, the subsoil is brought to the surface during tillage operations, thereby causing the surface soil to be slightly heavier than silty clay loam. In many fields there are small gray spots where the plow has cut into the upper part of the subsoil and brought the gray heavy clay to the surface. Here, the material below a depth of 6 inches consists of light-brown or yellowish-brown clay or heavy clay loam, that is not so tough or so impervious as the typical subsoil. Concretions of calcium carbonate are abundant at a depth of about 10 inches. In fields where these spots are numerous, yields are somewhat lower than average.

Although this is not an extensive soil, several fairly good sized areas are associated with the Pratt soils in the vicinity of Meno. A few areas occur here and there southeast of Fairview. The surface is smooth and generally rather flat. Drainage is imperfect in a few areas, but in most places the slope is sufficient to afford adequate drainage. The subsoil is so dense and so slowly penetrated by water that the almost flat surface is beneficial in preventing rapid run-off. Some difficulty is experienced in establishing a good stand of alfalfa on this heavy soil, but, once it has attained a good growth, alfalfa returns good yields.

Approximately 75 percent of the land is used for the production of wheat, 8 percent for alfalfa, 12 percent for row crops (largely corn, cotton, grain sorghums, and sorgo), and 5 percent is in native pasture. This soil appears well suited for the production of wheat and alfalfa, but is more commonly used for wheat. The tough clay subsoil is penetrated slowly by the plant roots and does not give up moisture fast enough to support vigorous growth during the hot dry periods of summer.

During seasons of normal moisture conditions yields of wheat are about 15 bushels an acre, cotton about one-fourth bale, corn 15 to 20 bushels, oats 20 to 25 bushels, grain sorghums 15 to 20 bushels, and alfalfa 2 to 3 tons. Yields of these crops fluctuate considerably from year to year, depending on the amount of rainfall during the growing season and on the amount of water stored in the subsoil. During the more favorable years the yield of wheat may be equivalent to that on any soil in the eastern part of the county. During favorable seasons, or ones following winters characterized by plentiful rains, alfalfa yields may exceed those given here.

The native vegetation probably consisted of big bluestem, but now buffalo grass and blue grama predominate. Where moisture conditions are favorable and the land has not been pastured, this soil supports a heavy growth of big bluestem and other coarse grasses and produces from 1 to 2 tons of hay an acre.

Calumet silty clay loam.—The surface soil of Calumet silty clay loam consists of brown or dark grayish-brown silty clay loam to a depth ranging from 4 to 10 inches. In many virgin areas the topmost 2 inches of material is very fine sandy loam. This material, when mixed with the material below during cultivation, causes lighter colored spots in the cultivated fields. The surface soil rests on or grades through a very thin short transitional layer into dark-brown or dark reddish-brown compact tough clay. Below a depth ranging from 24 to 30 inches the material is calcareous, looser in consistence, and coarser

in texture than that above and, in most places, contains a layer several inches thick, in which concretions of calcium carbonate are numerous. The heavy tough clay subsoil, therefore, is underlain by layers of soft friable clay and clay loam. Thin soft seams or lumps of gypsum are embedded in these lower layers. The depth to "Red Beds" material varies somewhat, but in most places it is about 80 inches.

Calumet silty clay loam is characterized by an almost level surface. Virgin pasture land is dotted with small depressions, about 8 feet in diameter and 10 inches deep, which are commonly called buffalo wallows. After the soil has been tilled for a number of years, however, these depressions are filled. In cultivated fields, small gray heavy clay spots are common, and they are locally referred to as slick spots or alkali spots. The lack of vegetation on the slick spots possibly may be due to the dry condition caused by the dense heavy clay rather than to a saline condition.

The soil appears to have developed on old stream terraces or beds of soil materials outwashed from higher lands, although no underlying beds of coarse erosional debris are noted. It covers an area of 18.6 square miles.

About 80 percent of this soil is cultivated, and the remainder is used for grazing land. Its productivity varies somewhat in different areas, depending on the depth to the claypan and the number of slick spots. Most of the areas, including a large number of buffalo wallows and slick spots, are used for pasture. Buffalo grass and blue grama grow well and produce a heavy sod. Although, in general, the ground is barren in the centers of the buffalo wallows, their borders are sufficiently well grassed that the barren areas do not greatly decrease the value of the land for pasture.

Wheat is the principal crop grown on this soil, and a small acreage is devoted to oats, cotton, grain sorghums, and alfalfa. During normal years yields of wheat are about 16 bushels an acre, grain sorghums 15 to 20 bushels, and alfalfa 1½ or 2 tons. Sudan grass yields about 2 tons of hay an acre, but neither this crop nor sorgo is grown to a great extent. Alfalfa is considered a desirable crop for this soil, and it is grown on a number of farms south of Fairview and along Deep Creek. According to local farmers, alfalfa produces well and maintains a better stand on this soil than on many of the other soils. It also improves the tilth of the surface soil, and its roots tend to break up the impervious claypan subsoil.

Surface drainage of Calumet silty clay loam is poor, but, except for the disadvantage this feature creates during tillage operations, the slow run-off is beneficial because the heavy subsoil can retain a large reserve of soil moisture. In most areas the deep subsoil remains moist, even during periods of severe drought, unless the moisture has been removed by alfalfa or other deep-rooted plants.

Approximately 80 percent of the cultivated land is used for the production of wheat, 12 percent for alfalfa, 5 percent for row crops (including grain sorghums, Sudan grass, sorgo, and corn), and 3 percent for miscellaneous crops. Vegetables do not grow well without irrigation in the drier seasons. Trees do not grow well, probably because of the dense subsoil.

Reinach silty clay loam.—The 6- to 12-inch surface layer of Reinach silty clay loam is brownish-red or reddish-brown silty clay

loam. It grades into dark-red clay or silty clay, which passes into red heavy silty clay loam. At a depth ranging from 18 to 36 inches this material, in turn, grades into light-red very fine sandy loam. The depth to the sandy material is variable. As a rule, calcium carbonate does not appear in the surface soil, but it is present in the lower part of the subsoil.

This is a very inextensive soil occurring mainly north of Fairview. The surface is flat, and the soil seems to have developed on old stream terraces that are crossed in many places by very shallow dry stream channels. Most areas of this soil are associated with Reinach clay, heavy-subsoil phase. Drainage is rather slow, especially after heavy rains, because the land is flat and the stream channels are shallow. Areas of a red clay soil, too small to map legibly, are included on the soil map.

Probably not less than 90 percent of this soil is in cultivation, and approximately 90 percent of the cultivated land is planted to wheat, as it is considered by farmers to be best suited for this crop. Various other crops, such as cotton, grain sorghums, sorgo, and alfalfa, are grown to a small extent. Grain sorghums and related crops produce fairly well in years of plentiful rainfall, provided a good stand is obtained. In years of average weather conditions wheat produces about 11 bushels an acre, cotton from one-fourth to one-half bale, kafir and milo about 12 bushels, and alfalfa and sorgo from 1 to 2 tons of hay. Alfalfa is grown to a small extent and in some years of maximum rainfall produces more than 2 tons an acre. Although this soil has characteristics similar to those of Reinach clay, it is not so well suited for alfalfa because of less subsoil moisture. Fruits and vegetables are not grown to a great extent on this soil.

Reinach clay.—The 6-inch surface layer of Reinach clay consists of red or brownish-red clay. It grades into red clay containing very little organic matter. In a few places, the surface soil contains concretions of calcium carbonate, and, in most places, the material is calcareous below a depth of 12 inches. Below a depth ranging from 18 to 36 inches and averaging about 22 inches is typically red loamy fine sand and fine sand, but in places the subsoil is much heavier.

This soil occupies small areas on the flat terraces bordering the flood plains of the Cimarron River north of Fairview. The land is very nearly level, and surface drainage is slow in most places.

Approximately 80 percent of this soil is in cultivation. Probably more than 50 percent of the cultivated land is planted to wheat and grain sorghums. This soil is considered by some farmers to be better suited for alfalfa than for most crops. Good yields of alfalfa are obtained, even in years of low rainfall. The porous subsoil probably receives seepage water, and the alfalfa is furnished with a plentiful supply of subsoil moisture during droughty periods. Probably the water table is high during much of the year. About 25 percent of the land is used for the production of alfalfa, and more could be successfully grown, especially if some artificial drainage were provided in the more poorly drained areas.

The surface soil of Reinach clay packs tightly on drying, especially in places where water remains for a short time following rains. This prevents a good stand of crops, although the surface soil, if cultivated properly, makes a good seedbed. Under favorable conditions,

grain sorghums yield about 15 bushels to the acre, wheat 10 bushels, and sorgo 1 ton.

Reinach clay, heavy-subsoil phase.—The 14-inch surface soil of Reinach clay, heavy-subsoil phase, consists of dark-red or reddish-brown clay, which, on drying, separates into distinct angular small particles. It grades into red or dark reddish-brown crumbly heavy clay, which in most places continues to a depth of more than 45 inches. In places below a depth of about 3 feet the material is dark-brown more or less calcareous heavy clay, which has the appearance of a buried soil. In some places the soil material is calcareous throughout.

Reinach clay, heavy-subsoil phase, is more extensive than the typical soil. The largest areas are north and northwest of Fairview. Other areas are southeast of Fairview and in the northwestern part of the county. The land is almost level, and drainage is comparatively slow. This soil is associated with other Reinach soils but occupies a slightly lower position than most of them. In places it receives run-off from adjacent areas of eroded "Red Beds" material or sheet wash from small streams issuing from "Red Beds" slopes. The soil seems to have developed on flats of outwashed "Red Beds" materials or old very high stream terraces.

Probably not more than 75 percent of this soil is in cultivation. Because it is closely associated with soils used mainly for the production of wheat, perhaps about 80 percent of the cultivated land is planted to that crop. The yield of wheat varies somewhat, but it is said to be an average of about 6 bushels an acre in years of average moisture conditions. Some alfalfa is grown, and in years of favorable moisture conditions it produces about 2 tons of hay to the acre. Grain sorghums are reported as not growing well on this soil, therefore they are planted to a very small extent. In areas where the surface soil is heaviest and densest, wheat yields are reported as only about 8 bushels an acre.

Many areas are used for pasture, and the native vegetation consists of a sparse covering of short grasses and a few scattered mesquite trees. The grasses consist mostly of blue grama, buffalo grass, side-oats grama, and dropseed grass. In places, as much as 50 percent of the land is barren.

Erosion and fresh deposition of heavy clay could be prevented largely by terracing the adjacent higher land and by diverting the run-off through drainage channels.

SOILS WITH SANDY SURFACE SOILS AND MODERATELY HEAVY TEXTURED SUBSOILS

Common features of the soils in this group are loose friable sandy surface soils and moderately heavy textured sandy clay subsoils. The areas are widely separated and are closely associated in most places with the lighter sandy soils. They are well suited to a wide range of crops and are productive.

An area of 61.7 square miles, or 6.4 percent of the land in the county, is covered by these soils. The relief ranges from nearly level to gently undulating. Surface and subsoil drainage are everywhere adequate except in Carwile fine sandy loam, which occurs in slight depressions where internal drainage, in most places, is slow. The

group includes Pratt fine sandy loam, Reinach fine sandy loam, Carwile fine sandy loam, and Carmen fine sandy loam.

The moisture that falls on the surface penetrates the soil very readily, and only a very small amount is lost through run-off or evaporation. The subsoils contain a sufficient proportion of very fine-textured material to produce a heavy consistence. The moisture-storing capacity is large, and fairly good yields of nearly all of the crops commonly grown are obtained, even in years of comparatively low rainfall, provided a reserve of water has been stored during the previous season. The organic-matter content of the surface soils is sufficient to produce fair yields of wheat. Although the surface soils are comparatively light textured, small damage is done to wheat by blowing in strong winds.

Pratt fine sandy loam.—Pratt fine sandy loam has an 8-inch layer of brown or dark grayish-brown fine sandy loam overlying brown or yellowish-brown loose friable fine sandy loam, which, at a depth of about 15 inches, grades into yellowish-brown or yellow fine sandy clay or clay loam. Below a depth ranging from 20 to 30 inches this material passes gradually into yellowish-brown loose loamy fine sand slightly mottled with gray in places.

According to field tests, the surface soil and subsoil are free of calcium carbonate, although the material doubtless is basic or neutral in reaction. Below a depth of about 40 inches, especially in the places where the subsoil consists of clay, concretions of calcium carbonate are present. The well-defined layer of accumulated calcium carbonate, so common in the lower subsoil layers of soils in the western part of the county, is lacking in this soil although it occurs in the same section.

Pratt fine sandy loam is of considerable extent. It covers an area of 26 square miles, or 2.7 percent of the county. This soil occurs in comparatively large areas, associated with other sandy soils on the upper plains in the southwestern part of the county but is more extensively developed in the eastern half. The surface is undulating or gently undulating. The surface soil is slightly lighter colored, and both the surface soil and subsoil are lighter textured and looser in the undulating areas than in the more nearly level situations. A variation from the typical soil, also associated with an undulating surface, includes areas in which the subsoil is reddish brown or faintly reddish brown.

This soil is well suited for the production of crops commonly grown in this section. Approximately 60 percent of the land is used for the production of wheat, 20 percent for grain sorghums and sorgo, 10 percent for cotton, and 5 percent is in native pasture. Although yields of crops on this soil depend to considerable extent on the moisture conditions, variations in yields from year to year are not so great as on the heavier textured soils. When the rainfall is ample for maximum yields on the heavy soils, yields on Pratt fine sandy loam do not increase proportionately; on the other hand, they are less affected by drought than those on some of the heavier textured soils. In normal seasons, acre yields of wheat are about 16 bushels, oats 18 to 25 bushels, grain sorghums about 25 bushels, sorgo from 2 to 3 tons of roughage, and cotton one-third bale. Vegetables are well adapted, and such fruits as peaches, apples, pears, plums, cher-

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ries, as well as berries, grapes, watermelons, cantaloups, and peanuts return good yields. Sudan grass, African millet, and cowpeas do well, but, with the exception of cowpeas, no large plantings of these crops are made. Corn produces well in a favorable season, but unfavorable yields during the last few years, because of low rainfall and hot winds, have tended to discourage the growing of this crop.

Reinach fine sandy loam.—The surface layer of Reinach fine sandy loam is brown or reddish-brown loose friable fine sandy loam, from 6 to 12 inches thick. This material grades into reddish-brown friable permeable clay loam. Beginning at a depth ranging from 14 to 20 inches, the subsoil consists of reddish-yellow fine sandy loam or reddish-brown loamy fine sand. According to field tests, neither the surface soil nor the subsoil contains calcium carbonate, although the lower part of the subsoil, in places, is calcareous and contains some small concretions of calcium carbonate. Beds of coarse sand and fine sand generally are present at a depth of several feet below the surface.

The relief of Reinach fine sandy loam, in most places, is very slightly undulating. Surface drainage is slow, and most of the rain water is absorbed by the permeable surface soil and subsoil.

This soil covers a total area of 19.8 square miles, or 2.1 percent of the land in the county. Perhaps 80 percent of the soil is cultivated. Most of the larger areas are north and southeast of Fairview, on the lower plain south and west of the Cimarron River, and in the northwestern part of the county. Most of the small areas are along small streams and drains. Because of the billowy surface and light-textured surface soil, many of the small areas are not well suited to crops, but they are cultivated in conjunction with the surrounding soils and constitute only a small part of the farms. Wind erosion is a serious problem on these areas, and special care must be given to their management. The soil occupies old stream terraces and smooth areas of old alluvium.

The organic-matter content is probably higher in this soil than in many of the other soils of the same texture, and fairly good yields are obtained. In normal seasons wheat produces about 14 bushels, grain sorghums 15 to 25 bushels, sorgo 1 to 2 tons of rough forage, and cotton one-fourth to one-half bale to the acre. Home orchards and gardens are on many farms. Small fruits, vegetables, and melons produce well in favorable seasons or where irrigated. Well water is available in most places and is used by many farmers for irrigating the home gardens. The soil is reported to be well suited to grain sorghums, small grains, and sorgo.

A large part of the land is cropped continually to wheat without an attempt to grow soil-improvement crops. A few farmers grow cowpeas and peanuts, but most of the land is planted to the farm crops that are generally grown on the heavier soils.

Carwile fine sandy loam.—The 6-inch surface layer of Carwile fine sandy loam is dark grayish-brown fine sandy loam, which grades into yellowish-brown fine sandy loam. Below a depth of 16 inches this changes abruptly to yellow or grayish-yellow fine sandy clay, grading, in many places, into slightly lighter material below a depth of about 28 inches. Calcium carbonate is present in places at a depth ranging from 19 to 24 inches.

This soil, locally called glade land, occupies basinlike areas in association with the looser sandy soils. Although surface drainage is slow, the subsoil is sufficiently permeable to allow free underdrainage. Open ditches are used where artificial drainage is necessary. Areas of this soil form a network through the Pratt and Tivoli soils. Many areas consist of irregular streaks intricately associated with Pratt and Tivoli soils. Very commonly in the middle or in the deeper parts of these areas the texture of the surface soil is clay loam. Here the surface soil tends to be darker and the subsoil is heavier and more mottled. Small closely associated areas of clay loam are included with the fine sandy loam on the map.

Carwile fine sandy loam is especially good cotton land. Well-drained areas also return good yields of wheat. Because this soil is generally suited to a great many crops, its value is somewhat above the average for the soils of this group. Many of the fruit orchards in the county are on this soil, and pears are said to produce especially well. In normal years, wheat yields about 14 bushels an acre, grain sorghums from 20 to 30 bushels, sorgo about 2 tons of rough forage, and cotton about one-half bale.

Carmen fine sandy loam.—The surface soil of Carmen fine sandy loam consists of grayish-brown or light-brown calcareous fine sandy loam to a depth of about 8 inches, where it is underlain by a 15-inch layer of light brownish-yellow or brownish-yellow fine sandy loam, which contains, in most places, hard concretions of calcium carbonate. This material passes gradually into yellow calcareous loamy fine sand. In places, especially in those slightly elevated above the surrounding land, concretions of calcium carbonate are on the surface. These concretions range in size from less than one-half to 2 inches or more in diameter and generally are embedded in chalky calcareous clay or marl.

A few very small areas of this soil have been included with the Tivoli and Pratt soils on the map. The subsoil in areas mapped with the Tivoli soils, several of which are about 9 miles east of Fairview and about 1 mile east of Isabella, is red and contains concretions of calcium carbonate at a depth of about 24 inches.

This soil is of slight extent. Most of it is west and south of Ames. It is almost level or slightly undulating and smooth. Surface drainage in most places is good, but underdrainage is slow.

It is possible that this soil has developed from ancient alluvium brought down from high areas in the river valley. Adjoining areas of the Tivoli and Pratt soils lie at slightly higher elevations. It is probable that seepage waters from these adjoining areas move laterally, strike the impervious and calcareous "Red Beds material," and, on evaporation, leave large quantities of calcium carbonate near the surface.

This soil is well suited for the production of grain sorghums, sorgo, and vegetables. Almost all of it is cultivated, and approximately 75 percent of the cultivated land is planted to grain sorghums. Nearly all of this soil is especially well suited for the production of tomatoes, onions, cantaloups, and watermelons. No fields of alfalfa were seen on this soil, but the crop probably would do well in some areas. Grain sorghums yield about 25 bushels an acre in good seasons.

SOILS WITH SANDY SURFACE SOILS AND SANDY SUBSOILS

The soils of this group are characterized by friable or loose sandy surface soils and deep sandy subsoils. They have little organic matter and are so loose that, where unprotected, they drift readily during heavy winds. Their total area is about 159.4 square miles, or 16.7 percent of the area of the county. They occur in widely separated bodies, generally in association with soils having slightly heavier sandy surface soils. The relief ranges from almost level to undulating. Moisture is absorbed readily but is not retained well, although it is readily given up to plants. Plants do not make so luxuriant a growth in early summer as they do on most of the heavier textured soils, owing to the lower productivity as compared with those soils. For this reason, the demand for moisture during droughty periods is not so great as in the heavier textured soils. Although a comparatively large amount of wheat is grown on these soils, grain sorghums, sorgo, peas, peanuts, fruits, vegetables, and watermelons are grown to a greater extent than on the soils of the other groups. Yields of milo and related crops are not high, but crop failures are practically unknown. Pratt loamy fine sand, Tivoli fine sand, Enterprise loamy very fine sand, St. Paul loamy very fine sand, Reinach loamy fine sand, and Canadian loamy fine sand comprise this group.

Pratt loamy fine sand.—Pratt loamy fine sand differs from Pratt fine sandy loam principally in the coarser texture and lighter color of both surface soil and subsoil. The calcium carbonate layer also is less distinct and lies at a greater depth than in that soil. Pratt loamy fine sand has a grayish-brown or light-brown loose loamy fine sand surface layer, about 12 inches thick. This grades into a 24-inch layer of yellowish-brown friable heavy loamy fine sand. Below a depth of 36 inches the material consists of yellow heavy fine sandy loam, which, in most places, grades into yellow fine sandy loam or loamy fine sand at a depth of about 48 inches. As a rule, neither the surface soil nor the subsoil is calcareous.

The principal variations are slight differences in the texture of the surface soil and subsoil and in the depth to the fine sandy loam subsoil. Mapped areas of this soil include small areas of Tivoli fine sand, Pratt loamy fine sand, dune phase, and Pratt fine sandy loam, which are too small to show separately.

Pratt loamy fine sand is an extensive soil, covering an area of 76.1 square miles, or 8 percent of the total area of the county. It is associated with Pratt fine sandy loam as well as with many other sandy soils on the upper plain in the southwestern part of the county and in the eastern part on both sides of the Cimarron River. Most areas of this soil generally are level, although some are gently undulating or sloping or are slightly depressed and surrounded by Pratt loamy fine sand, dune phase. The large areas south and east of Ames are level, and the characteristics of the soil in these areas are rather uniform. Very little rain water is lost by run-off, owing to the permeability of the soil throughout.

Probably about 85 percent of this soil is in cultivation. It is suited to about the same crops as is Pratt fine sandy loam, but the average yields are somewhat lower than on that soil. Crops appear to withstand dry conditions somewhat better on Pratt loamy fine sand. Approximately 65 percent of the cultivated land is used for the pro-

duction of wheat, 30 percent for row crops (including milo, kafir, sorgo, peas, broomcorn, and corn), and 5 percent for cotton and miscellaneous crops. Aside from the section south and east of Ames, where wheat is grown rather extensively in the large level areas, probably not more than 50 percent of the cultivated land is devoted to this crop. This soil is so friable that it may be tilled easily and kept in good loose condition in cultivated fields. In years of normal moisture conditions wheat yields about 13 bushels an acre, cotton one-fourth bale, grain sorghums 20 to 30 bushels, and sorgo 1 to 2 tons of rough forage.

Pratt loamy fine sand is probably as well suited to as many different crops as any soil in the county. Home orchards and gardens generally are planted on this soil where possible, and, with some attention given to management of the orchards, apples, peaches, pears, and cherries, as well as grapes and bush fruits, produce fairly well during favorable seasons. Vegetable crops are grown largely for home use. Water from windmill pumps is used for irrigating the gardens on many farms. Few watermelons and cantaloups are grown for the market, but many squashes and citrons (locally called pie melons) are produced for home canning and as feed for livestock.

The productiveness of this soil remains fairly constant over a period of years after it has been placed in cultivation. Satisfactory results are obtained by growing soil-improvement crops, and cowpeas are coming into more common use for this purpose. Despite its rather light texture, this soil does not blow and drift greatly where protected by growing vegetation. The native pasture plants are fairly nutritious. Although coarse grasses predominate, some short grasses, such as buffalo, blue grama, and side-oats grama, afford good grazing.

Tivoli fine sand.—The surface soil of Tivoli fine sand, to an average depth of 10 inches, is light-brown or light grayish-brown loose fine sand underlain by light brownish-yellow fine sand, which, at a depth of about 20 inches, passes into light-yellow fine sand. In some places the subsoil below a depth of 30 inches consists of light-yellow or reddish-yellow loamy fine sand or heavy loamy fine sand. As a rule, neither the surface soil nor the subsoil is calcareous. In a few areas east of the Cimarron River, in the vicinities of Cleo Springs and Ames, however, the subsoil contains some calcium carbonate, generally at a depth of about 2 feet.

In a small area included with Tivoli fine sand in secs. 2 and 11, T. 23 N., R. 16 W., the soil consists of light reddish-brown loamy fine sand to a depth of 8 inches. This material grades into light-red loamy fine sand, which contains concretions of calcium carbonate. Below a depth of 20 inches this, in turn, is underlain by reddish-yellow highly calcareous coarse sand. Farmers report that crops suffer quickly on this soil in dry seasons.

A total of 61.2 square miles, or 6.4 percent of the area of the county, is mapped. The soil is associated with sandy soils of the Pratt and Carwile series. This soil is more extensive in the eastern part of the county than elsewhere. The largest areas are northeast of Ames and northwest and east of Cleo Springs. Some of the areas range from 2 to 6 square miles in extent.

The relief of Tivoli fine sand is undulating and billowy. In some of the large areas northeast of Ames, however, the surface is almost flat. Practically no water is lost by run-off, as most of it moves downward through the porous material. Good water is obtained in wells ranging from 16 to 30 feet in depth.

The native grass vegetation consists of little bluestem, sand dropseed, side-oats grama, wild-rye, blue grama, buffalo grass, and needlegrass. Coarse and bunch grasses are much more abundant than short grasses. The trees on this soil, in areas that have not been cleared for cultivation, consist of blackjack oak, some bur oak, and post oak.

Tivoli fine sand is one of the lightest textured soils of this group, but it is used, nevertheless, for the production of as many different kinds of crops as is any soil in the county. Probably not less than 80 percent of the land is in cultivation. It is said that crops withstand dry weather or droughty conditions rather well on this soil. Yields are not high, even in years of comparatively high rainfall, but in dry seasons when crops make very light yields or fail on many of the heavier soils, fair yields are obtained on this soil. Under favorable conditions wheat yields about 9 bushels an acre, grain sorghums 15 to 20 bushels, cotton one-eighth to one-fourth bale, sorgo from 1 to 2 tons of rough forage, Sudan grass about 2 tons of hay, and corn about 11 bushels. Grain sorghums, peas, peanuts, fruits, vegetables, and berries, especially blackberries and gooseberries, grow well. Although most of the fruits and vegetables produced are in home orchards and gardens, a number of small commercial orchards of bush fruits are in the eastern part of the county, and some onions, watermelons, potatoes, sweetpotatoes, cucumbers, tomatoes, and turnips are grown on a commercial scale, especially in the areas east and southeast of Cleo Springs.

The texture of Tivoli fine sand is rather light for the most satisfactory production of wheat, but the crop is grown with fairly good results, although not so extensively as on the heavier textured soils. The soil blows and drifts severely where unprotected. Many fields, which have been planted to wheat for many years in succession, have lost a rather large part of the surface soil by blowing and have been abandoned. Farmers find it best to leave the surface rough during the winter, allowing vegetation and trash to remain without being plowed under. Where wheat is grown, especially where cowpeas have been harvested previously, the land generally is bedded with straw. Areas most severely affected by wind action are those northwest of Cleo Springs where the soil is lighter textured than it is in most of the other areas.

Approximately 40 percent of the cultivated soil is used for the production of wheat, 30 percent for grain sorghums, 15 percent for peas, 10 percent for fruits and vegetables, and 5 percent for peanuts and beans. Broomcorn is grown in the western part of the county, but the acreage planted to this crop is not large and fluctuates from year to year.

Enterprise loamy very fine sand.—The surface soil of Enterprise loamy very fine sand is reddish-brown loamy very fine sand to a depth ranging from 6 to 10 inches. This grades into red loose very fine sand or loamy very fine sand. Below a depth of 55 inches, the material

consists of loamy very fine sand, which appears, in many places, to be cross-bedded. According to field test the surface soil and subsoil layers are not calcareous.

Practically all the land could be farmed, provided care were taken to prevent wind and water erosion, but only about 35 percent of it is in cultivation. Grain sorghums are the leading crops grown. Milo and kafir yield about 12 bushels an acre. The areas not topographically suited to cultivation are used for pasture land.

The native vegetation consists of coarse grasses, which include little bluestem and needlegrass. In places some blackjack oak trees grow, together with various shrubs, including wild plums, artemisia, sumac, shin oak, and others.

Enterprise loamy very fine sand is an inextensive soil and is mapped principally on the eastern side of the Cimarron River near the Harron and Hog Ranch Schools. Areas are in the western part of the county on the northern extremities of the high divides, and here the surface is rolling to billowy.

The areas in the eastern part differ somewhat from those in the western part in having a darker colored surface soil and a slightly heavier subsoil. In a few places, concretions of calcium carbonate are numerous in the subsoil and, in places, lie within about 24 inches of the surface. Here, the relief is only slightly undulating or billowy. Approximately 70 percent of this land is cultivated, and probably about 60 percent is planted to wheat. Wheat yields average about 12 bushels an acre and grain sorghums about 20 bushels. Some cotton is grown on these areas, and during favorable seasons it produces about one-fourth bale an acre.

St. Paul loamy very fine sand.—St. Paul loamy very fine sand differs somewhat from St. Paul very fine sandy loam in having a lighter texture in both surface soil and subsoil. Locally, it is sometimes called red sandy land. The surface soil is reddish-brown or brown friable loamy very fine sand, to a depth of about 10 inches. This material passes gradually into brown slightly heavier friable loamy very fine sand, which has a mellow crumbly structure. Below a depth of about 36 inches, this, in turn, grades into red or light reddish-brown friable very fine sandy loam. Sandy "Red Beds" material underlies the soil at a depth ranging from 4 to 6 feet.

In most places the surface soil and upper subsoil layers are free of calcium carbonate. Below a depth of about 36 inches an accumulation of calcium carbonate is indicated by the presence of hard and soft concretions. Where the subsoil is lighter in texture than very fine sandy loam, the material generally is rather free of calcium carbonate.

This is not an extensive soil. A few small areas are in the western part of the county north and east of Sherman. The relief ranges from smoothly undulating to very nearly level. Surface drainage is slow, and the porous subsoil is so permeable that most of the rain water is absorbed and retained.

Farmers consider this soil to be suited to the production of both wheat and row crops, including grain sorghums, Sudan grass, sorgo, and cotton. Probably 95 percent of the land is under cultivation, and approximately 65 percent of the cultivated land is used for wheat, 30 percent for grain sorghums, sorgo, and Sudan grass, 3 percent for

cotton, and 2 percent for miscellaneous crops. Although the yields of wheat on this soil are slightly lower than those on St. Paul very fine sandy loam, the yields of row crops are approximately the same on the two soils. Wheat yields about 12 bushels, grain sorghums 20 to 30 bushels, Sudan grass about 2 tons of rough forage, sorgo about 1 ton, and cotton about one-eighth of a bale an acre.

St. Paul loamy very fine sand is so friable that it may be tilled easily and kept in good loose condition in cultivated fields, but the surface soil blows severely in dry windy seasons, in places where it is not properly cultivated. A few areas of this soil are slightly rolling to billowy, and yields are relatively low in such places, owing to the comparatively lighter texture of the surface soil and the greater tendency of the material to blow. Most of the soil utilized for pasturage is covered with short grasses, including buffalo grass and blue grama, some bunchgrass, and, in places, considerable sagebrush. In a few areas east of Sherman, an included soil, having a fine sandy loam surface soil, resembles Pratt fine sandy loam, but it differs from that soil in having a red subsoil overlying very fine sandy material of the "Red Beds" formation.

Reinach loamy fine sand.—The 6-inch surface soil of Reinach loamy fine sand is brown or light-brown loose loamy fine sand, which grades into light-brown or reddish-brown loose loamy fine sand. Calcium carbonate is not present in the subsoil, except in a few areas adjacent to drains and bottom lands.

This soil occurs in fairly large areas southeast of Fairview and in the vicinity of Orienta. Smaller areas border most of the smaller streams and drains and probably are developed from old alluvium. The surface in general is gently undulating to hummocky, but in a few places it is billowy. Because of the permeable material, most of the rain water is held by the surface soil and subsoil.

This soil is considered poor cropland, and probably not more than 60 percent of it is in cultivation. Although more than 50 percent of the cultivated land is planted to wheat, farmers consider grain sorghums, sorgo, and other forage crops to be better adapted for this soil. Yields of wheat average about 8 bushels, grain sorghums (including kafir, milo, and feterita) about 19 bushels, cotton about one-eighth bale, and sorgo 1 to 2 tons of rough forage. Some corn is grown, but unless the season is particularly favorable for maturing the grain, it is usually harvested as rough forage.

Where cultivated the light surface soil blows severely in winds, and in some narrow strips along drains and bottom lands, the soil is so loose that it is not highly productive for most farm crops. All layers are readily permeable by water, thus allowing leaching, and, therefore, the water-holding capacity is low. The fertility is comparatively low, and the growth of crops is not heavy during the early summer. Less attention is given to the planting of soil-improvement crops on this soil than on most of the other sandy soils.

The native vegetation consists of short grasses, including buffalo, blue grama, and some bunchgrass. This land affords fairly good pasturage, but where the surface is billowy the grasses are more sparse.

Home orchards and gardens are common on this soil, but fruits and vegetables do not return satisfactory yields, except during the more favorable years.

Canadian loamy fine sand.—The 10-inch surface layer of Canadian loamy fine sand is brown or grayish-brown loose loamy fine sand, which grades into light-brown loose loamy fine sand. Below a depth of 16 inches, this passes into light yellowish-brown or light reddish-brown friable loamy fine sand containing calcium carbonate in the form of disseminated particles. In many places the upper part of the subsoil does not contain calcium carbonate, but generally it is present at a depth of about 2 feet. The lower part of the subsoil differs little from the upper part, except in a few places where the interbedded layers of loamy fine sand and very fine sand are distinct.

This soil occurs in a few small areas in the extreme southwestern part of the county north of the North Canadian River. These areas are flat or slightly sloping and, in most places, occupy terraces, which lie a few feet above the Lincoln soils and between those soils and the Tivoli soils.

Probably not less than 90 percent of this soil is cultivated. Grain sorghums, sorgo, and wheat are the principal crops, but a small acreage is devoted to broomcorn, cotton, and oats. Grain sorghums yield about 20 bushels an acre, wheat about 11 bushels, cotton about one-fourth bale, and oats about 20 bushels. It is said that alfalfa does not produce well because of the light texture of the soil. Peanuts, melons, and vegetables are successfully grown in areas slightly elevated above the Lincoln soils, and possibly sweetclover could be grown in these areas.

This soil is loose and very pervious. Although little rain water is lost by run-off, the reserve of water is not large over a long period of drought. Owing to the small content of plant nutrients, crops do not make so luxuriant growth or withstand dry conditions so well as some of the crops on the heavier textured soils of this group. The surface soil blows severely where unprotected.

Uncultivated areas of Canadian loamy fine sand are covered with bunchgrass, some short grasses, and some sagebrush. The grass cover is not heavy, and the land is not considered very valuable for pasture.

ARABLE SOILS OF THE BOTTOM LANDS

Soils of this group occupy the flood plains along the streams. The soil materials that constitute the principal soils of the group have not been greatly altered by soil development, and their characteristics are much like those of the original soils from which they were removed by erosion. They all, especially the Lincoln soils, have been unmodified by an accumulation of organic matter since deposition. These soils cover an area of 50.4 square miles, or 5.3 percent of the county. The larger areas are along the North Canadian and Cimarron Rivers. In these bottom lands the water table is, in most places, about 10 feet beneath the surface. In many places, however, it is much nearer the surface, and the subsoils are well supplied with moisture even in the drier years. In places the soils contain a considerable quantity of soluble salts.

The soils of the stream bottoms comprise soil materials which have been washed from the soils of the plains. Those formed from materials derived largely from the "Red Beds" formation are calcareous

and red or reddish brown, whereas those that are not red are formed from materials derived largely from the brown and light-brown plains soils.

The soils of this group are Lincoln loamy very fine sand, Lincoln silt loam, Lincoln very fine sand, Yahola very fine sandy loam, Yahola fine sandy loam, and Yahola clay.

The surface of these soils is level, with the exception of slight elevations and depressions along old channels as a result of deposition of materials by the swifter currents during floods. In many of the wider bottoms, surface drainage is slow. Some of these soils are subjected to frequent overflows, but most of them lie from 3 to 6 feet above the stream channels, so that water drains off in a few hours after the streams subside.

The organic-matter content and inherent productivity of these soils is comparatively high. Corn, grain sorghums, alfalfa, and other feed crops are grown successfully. The moisture conditions, on some of the soils especially, favor the growth of alfalfa. Small grains also do well, but they have a tendency to produce a rank growth and lodge. Much of the land is in such narrow strips and is so cut or broken by stream channels that large machinery cannot be used. Such land probably is best utilized for the production of feed crops or for pasture.

Lincoln loamy very fine sand.—The surface soil of Lincoln loamy very fine sand is medium-gray, dark-gray, or grayish-brown loamy very fine sand, about 5 inches thick. This grades into yellowish-gray very fine sandy loam or loamy very fine sand. Below a depth of 15 inches this passes gradually into pale yellowish-brown and then into light-gray incoherent very fine sand. In a considerable area occupied by this soil, the deep subsoil is comprised of alternating layers of loamy very fine sand and very fine sandy loam and is somewhat mottled or splotched with gray. As a rule, both the surface soil and the subsoil are calcareous.

This soil is developed only in the bottom lands along the Cimarron and North Canadian Rivers. The surface is prevailingly flat except where relieved by old stream channels and sloughs. Natural drainage of this soil is slow, and the water table is high. Drainage is sufficient for farming operations, except in very wet seasons.

Lincoln loamy very fine sand is suited to a wide range of crops. Approximately 80 percent of it is cultivated. Kafir and milo are the most important crops, and during favorable seasons they yield about 25 bushels to the acre. Cotton and alfalfa also are grown. Cotton produces one-fourth to one-half bale an acre. The land, in most places, is too sandy to obtain a good stand of alfalfa, but where a good stand is obtained, this crop produces well, principally because of the underground supply of soil moisture. Under such conditions, alfalfa generally produces four cuttings of hay with a total yield of about 3 tons an acre. Truck crops, including melons and cantaloups, do well and are produced on a considerable acreage. Much of the land is too light textured for good yields of small grains, although oats do well in places where the subsoil is slightly heavier than is typical. A small quantity of wheat is grown, but yields are low.

Many areas of Lincoln loamy very fine sand are too small to be shown on the soil map and are included with Tivoli fine sand, dune

phase. These areas afford good pasturage, and, in many places, about 1½ tons of hay an acre is cut. The native vegetation consists of big bluestem, blue grama, side-oats grama, little bluestem, and other grasses.

Several small areas of this soil are irrigated by water pumped from wells by windmills. Practically all of the vegetables grown are for home use or for local consumption.

Lincoln silt loam.—The surface layer of Lincoln silt loam is dark grayish-brown friable silt loam about 4 inches thick. It grades into a 9-inch layer of very dark grayish-brown or dark-gray silty clay loam. This is underlain by dark-gray silty clay mottled with light gray. At a depth of about 20 inches, the material passes gradually into a layer of light-gray silt loam about 10 inches thick. Below this the material consists of light-gray and light-yellow loose loamy very fine sand. Both surface soil and subsoil are comparatively friable, although in places the upper part of the subsoil consists of clay and contains an abundance of calcium carbonate. The texture and thickness of both surface soil and subsoil are rather variable, owing to differences, from place to place, in sedimentation from overflow waters.

This is a very inextensive soil, all which lies on the flood plain of the North Canadian River, in the southwestern part of the county. The surface of the soil lies from 6 to 10 feet above the stream bed of the river, and most of the time good drainage prevails, although the surface is slightly depressed. Little damage to crops is caused by flooding, except in occasional seasons of very high rainfall.

Probably 80 percent of the land is cultivated and is used for the production of grain sorghums, cotton, onions, melons, tomatoes, and other vegetable crops. Melons and vegetables do especially well. Yields on this soil do not vary greatly because of a plentiful supply of subsoil moisture. Where artificial drainage is provided, alfalfa produces about 3 tons of hay an acre. Kafir and milo produce about 25 bushels, and cotton about one-half bale. In some places soluble salts cause some damage to cultivated crops, but such areas generally are used for pasture. The native grasses consist of coarse grasses, some saltgrass, and, in places, buffalo grass.

Lincoln very fine sand.—The 10-inch surface soil of Lincoln very fine sand consists of light-brown or light grayish-brown incoherent very fine sand. It is underlain by light-yellow fine sand slightly mottled with gray. Both the surface soil and the subsoil are calcareous.

This soil is closely associated with the Tivoli soils and Lincoln loamy very fine sand along the northern side of the North Canadian River and along the northern side of the Cimarron River, especially southwest, south, and southeast of Cleo Springs. The surface is flat, except in a few places where recent wind movement has caused it to become billowy. The land lies about 8 feet above the river bed, and during periods of heavy rains is subjected to overflow. In places seepage and run-off water from adjacent sandy lands of the upland cover the surface for short periods.

Probably 50 percent of this soil is cultivated. Because of its light-textured surface soil and subsoil and its low organic-matter content, together with its low inherent fertility, it is used almost entirely for the production of grain sorghums and sorgo. Yields are very low,

especially after the organic matter has been dissipated from the virgin soil and the surface soil has been shifted by the wind. Large blow-outs have formed in cultivated areas, particularly where little attention has been given to protecting the soil from blowing. It is apparent that the best use of this land is for pasture. The native grasses are mainly side-oats grama, big bluestem, redtop, little bluestem, sandgrass, and dropseed.

Yahola very fine sandy loam.—The surface layer of Yahola very fine sandy loam is reddish-brown or brownish-red very fine sandy loam, 6 or 8 inches thick. It grades into brownish-red friable very fine sandy loam, and this is underlain, at a depth ranging from 38 to 44 inches, by lighter brownish red very fine sand or fine sand, which continues downward for several feet. The soil is calcareous throughout. In many places the subsoil contains layers of finer textured materials ranging from silt loam to clay loam or clay. In general, the texture is lighter in the lower part of the subsoil than it is in the surface soil or upper part of the subsoil. Included in mapping are areas of Yahola fine sand, Yahola loamy very fine sand, and Yahola silt loam, which could not be separated on a small-scale map. As a rule, the more uniform areas occur in the wider bottom lands.

This soil occupies narrow bottoms of streams issuing from the upper plain, and a few fairly large areas are on the wide bottoms of the Cimarron River. The surface is flat and, in a few places, slightly depressed; but drainage is fairly good, as the light-textured subsoil and substratum allow fairly good underdrainage. The areas along the smaller streams are, in most places, narrow and are cut by channels.

Probably not more than 50 percent of the land is cultivated. The soil is naturally rather productive, and in years of average rainfall and when crops are not damaged by flooding, grain sorghums yield about 25 bushels an acre, cotton about one-half bale, Sudan grass from 2 to 3 tons of hay, sorgo about 2 tons of rough forage, and alfalfa 2 to 3 tons of hay. A very small acreage is devoted to small grains, although the yields are comparatively high. Approximately 75 percent of the cultivated land is used for the production of grain sorghums and the rest for cotton and feed crops. Probably not more than 5 percent is sown to alfalfa, but in many places the land is as well suited to this crop as to any other. Sweetclover probably could be grown with success.

The native grasses, namely, side-oats grama, wild-rye, sand dropseed, some bunchgrass, needlegrass, and buffalo grass, afford good pasturage.

Yahola fine sandy loam.—The 12-inch surface soil of Yahola fine sandy loam is red or reddish-brown fine sandy loam. This grades into red loamy fine sand, which rests, at a depth of 18 inches, on layers of various thicknesses and textures. In the Cimarron River bottom land this soil, in many places, is underlain by light-yellow fine sand. Calcium carbonate is present in both surface soil and subsoil.

Included on the soil map are areas of loamy fine sand, fine sand, and even loamy sand or loamy coarse sand (all of the Yahola series), which are too small to warrant separation.

Most of the areas of Yahola fine sandy loam occupy narrow bottoms of streams and drainageways in the northwestern and central parts of the county. The widest strips border Ewers, Grever, and Eagle Chief Creeks.

Areas of this soil are almost flat, although there are a few slight undulations. Most of the land in the narrow stream bottoms is so uneven and cut by stream channels that farming is not practical. Only about 30 percent of the soil is cultivated, owing to the small size of the individual areas, their inaccessibility, and danger of overflow. Grain sorghums, sorgo, Sudan grass, and corn are the principal crops grown on the cultivated areas. Very little alfalfa is grown, although farmers report that it produces well in favorable years. Grain sorghums yield about 20 bushels to the acre in favorable years; sorgo, 1 to 2 tons of rough forage; and Sudan grass, 2 tons of hay. Native grasses on this soil include sand dropseed, buffalo grass, blue grama, side-oats grama, and some needlegrass, wild-rye, and bluestem (locally called western wheatgrass). The good growth of grasses renders this land valuable for grazing.

Yahola clay.—The surface soil of Yahola clay, to a depth ranging from 10 to 20 inches, is red or brownish-red clay, which is underlain in most places by red fine sand and loamy fine sand, occurring in layers of variable thickness. The surface soil is rather heavy and slowly permeable. Under favorable moisture conditions, however, when cultivated properly, it works into a crumbly friable condition. Both surface soil and subsoil are calcareous. In the bottom land of the Cimarron River the subsoil is lighter textured and, in most places, lies nearer the surface than in the small stream bottoms. Moisture conditions in these areas are less favorable for growing crops.

Areas mapped as this soil in the vicinity of Cleo Springs include a few areas of Yahola clay loam. In some places the texture of the subsoil is heavy, but, as a rule, sandy material is present at a depth of less than 30 inches.

Yahola clay covers an area of 27.1 square miles, or 2.8 percent of the land area of the county. The widest bodies are along the Cimarron River. Narrow strips border most of the creeks and minor drainageways (pl. 2, *B*). The areas are flat and, in places, slightly depressed. Because of the light subsoil and substratum, underdrainage is good, although in places, particularly in the slightly depressed areas along the Cimarron River, surface drainage is slow.

Probably not more than 30 percent of this soil is cultivated, and the rest is covered with short grasses, including buffalo grass and blue grama, and a scattered growth of trees, including elm, ash, chinaberry, gum elastic (chittamwood), and some cottonwood. In many areas along the Cimarron River the grass cover consists of side-oats grama, dropseed, bluestem (western wheatgrass), and saltgrass.

The principal crops grown on this soil are grain sorghums, sorgo, corn, alfalfa, and some cotton and wheat. Although fairly well suited for these crops, the soil is rather heavy for best yields of vegetables and fruits. In years of favorable moisture conditions, cotton yields as much as one-half bale to the acre, grain sorghums about 16 bushels, wheat 18 bushels, Sudan grass from 2 to 3 tons of hay, and sorgo about 2 tons of rough forage.

SOILS GENERALLY UNSUITED FOR CULTIVATION

Included in this group are several soils, phases, and land types, which are unsuited for producing cultivated farm crops, owing either to unfavorable physical features, unfavorable chemical constituents,

or low productivity. The total area of these soils is 444.6 square miles, or 46.6 percent of the area of the county. Three subdivisions of this group may be made: (1) Loose deep sands of low productivity; (2) eroded and broken land; and (3) smooth imperfectly drained or saline soils.

In the first subdivision are Tivoli fine sand, dune phase, Pratt loamy fine sand, dune phase, and Pratt loamy coarse sand. These soils are physically unsuited for farm crops and are also deficient in some of the essential plant nutrients. They drift greatly in heavy winds where not protected by vegetation. Grazing probably is the best use for these soils. The rainfall is completely absorbed, and coarse grasses and shrubs flourish. In places a fairly heavy growth of small oak trees provides a valuable source of firewood.

The second subdivision comprises Vernon very fine sandy loam, broken phase, Vernon-Fairview complex, Vernon clay, eroded phase, rough broken land (Vernon soil material), and rough broken land (Quinlan soil material). This land supports a moderate growth of short and some coarse grasses and provides good grazing and shelter in severe cold weather.

The smooth soils, which nevertheless are unsuited for farm crops, include Carwile clay, Lincoln clay, imperfectly drained phase, Lincoln clay, saline phase, Yahola loamy very fine sand, and riverwash. In some areas of these soils, a thin cover of grasses provides scant pasturage. Some of the soils, however, are practically bare of native vegetation.

Tivoli fine sand, dune phase.—Tivoli fine sand, dune phase, consists of wind-drifted sand dunes. The soil consists of grayish-brown loose fine sand to a depth of several inches, where it passes into yellowish-brown or light reddish-brown loose fine sand, which continues to a depth of many feet. In the more recently blown material the soil is grayish-brown loose deep fine sand throughout. None of the soil layers is calcareous.

The relief is undulating to billowy and very dunelike. In places near the river bottoms some very steep ridgelike dunes, almost bare of vegetation, rise to a height ranging from 30 to 40 feet. The principal growth of the areas free of trees comprises coarse grasses and shrubs of sumac, a species of sage locally called sand sage, wild plum, and others. In places calcareous wind-blown sandy material is received from the looser soils of the stream bottoms. Fairly large areas are covered with blackjack oak trees, which range from very small to more than 20 feet in height. Here, the sand is stabilized and does not blow as in the treeless areas (pl. 3, *A*).

A wide almost continuous belt of this soil follows the northern bank of the Cimarron River from the Woods County boundary west of Cleo Springs to the southern county line, and a similar belt follows the northern bank of the North Canadian River in the southwestern part. Smaller areas are scattered throughout other parts of the county. Altogether, these areas total 167.4 square miles, or 17.6 percent of the area of the county.

This soil is entirely unsuited for cultivation and is of very limited value even for grazing livestock. In some areas mapped as this soil the dunes are separated by narrow strips of sandy soil, somewhat heavier than that in the dunelike areas. The grass cover in these low

areas is more nutritious and palatable and adds to the grazing value of the land.

Pratt loamy fine sand, dune phase.—Pratt loamy fine sand, dune phase, is similar to Pratt loamy fine sand, but it is unsuited to cultivation because of the very loose character of the soil and its dunelike relief. The 6-inch surface layer consists of light-brown loamy fine sand, which grades into a 10-inch layer of heavy yellowish-brown loamy fine sand. Below this, in most places, is yellow fine sand or loamy fine sand. In some places, particularly in areas bordering the heavier sandy lands or those in which the Red Beds formation lies near the surface, the texture of the material below a depth of 24 inches is heavy clay loam or clay.

Forest covers this soil, except the areas that have been cleared for pasture or for cultivation. The principal tree is blackjack oak, and some post oaks and bur oaks grow. The cleared areas support a good cover of nutritious grasses, consisting of big bluestem, little bluestem, and some blue grama, black grama, and side-oats grama. Areas mapped as this soil include small depressions that are well covered with buffalo grass and blue grama.

This soil covers an area of 40.6 square miles, or 4.3 percent of the land in the county. It is widely distributed in the parts having loose sandy soils, mainly in the eastern and southwestern sections. The relief ranges from strongly undulating to rolling. Surface run-off is very slight, and nearly all of the rain water passes through the porous material rapidly. On the steeper slopes in some of the cultivated areas, erosion by wind or water has been excessive. Small areas of the Carwile soils, Pratt fine sandy loam, and Pratt loamy fine sand are included in mapping.

This soil is used principally for grazing. Probably less than 10 percent is cultivated. Most of the land in cultivation is farmed in conjunction with the surrounding soils and constitutes only a small part of the fields. Fruit orchards do well, especially in places where the subsoil consists of fine sandy clay or clay loam. There are a few commercial orchards producing peaches, apples, and cherries, in the eastern part of the county. Most farmers consider fruit growing one of the best uses for this soil wherever the farmstead is close to an area of it, especially if the subsoil is rather heavy.

Pratt loamy coarse sand.—Pratt loamy coarse sand has a 5-inch surface layer consisting of loamy coarse sand. It is underlain by light-yellow loamy fine sand or fine sandy loam, containing a high proportion of fine gravel. At a depth of about 18 inches, the material changes abruptly to light-yellow or light yellowish-brown clay. The subsoil is calcareous below a depth of 20 inches, and in places calcium carbonate is present within a depth of 2 or 3 inches.

This soil occurs chiefly in a few narrow areas in the western part of the county south of Sherman. Most of it occupies high divides along the escarpment, where a thin layer of heavy clay or Tertiary material overlies the "Red Beds" formation. The relief is rolling or gently rolling. The heavy clay in the lower part of the subsoil is penetrated slowly by water, and the sloping surface causes rapid run-off and excessive erosion. Some gravel and coarse sand obtained from beds beneath the soil are used for surfacing roads.

Variations consist of small spots or bodies, in which small water-worn rocks and pebbles are scattered over the surface and a thin heavy layer is present at a depth of about 18 inches.

Probably less than 20 percent of this soil is cultivated, and most of this is farmed in conjunction with other soils. The grass cover is thin, and its value for grazing is about equal to that on Tivoli fine sand, dune phase. It consists of buffalo grass, grama, needlegrass, and some little bluestem.

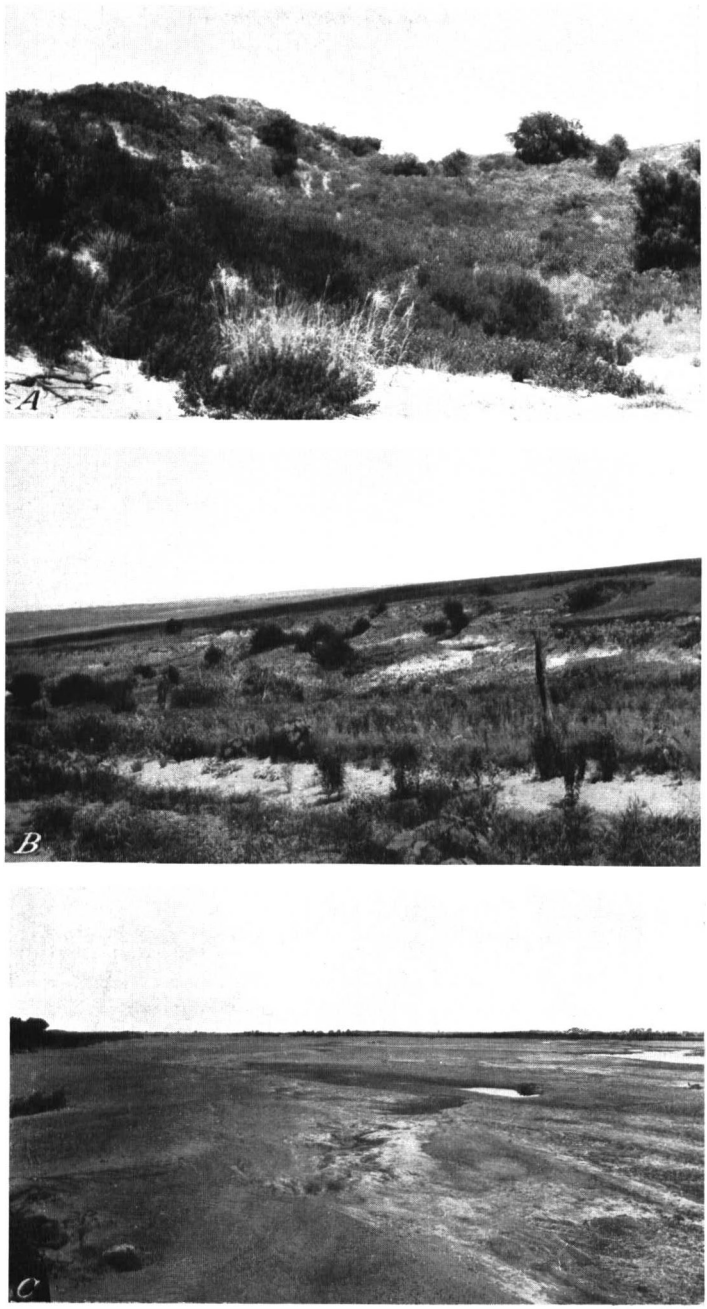
Vernon very fine sandy loam, broken phase.—Vernon very fine sandy loam, broken phase, comprises steeply sloping narrow areas along drains dissecting the smooth plain in the northeastern part of the county. The land is too steep for cultivation and in many places is gullied and severely eroded, exposing "Red Beds" clays, shales, and sandy formations (pl. 3, *B*). Severe erosion has thinned the surface soil, which, in the less eroded areas, consists of a 2- to 4-inch layer of dark reddish-brown calcareous very fine sandy loam. This grades into an 18-inch layer of light-red clay loam containing a few concretions of calcium carbonate. In some areas, however, the concretions are abundant. Beneath this layer the material consists of "Red Beds" clays, shales, and sandy formations.

This land affords good pasturage in most places from the fairly thick growth of blue grama, side-oats grama, buffalo grass, and some bluestem and needlegrass. Approximately 8 acres of pasture land are required to sustain each animal. Some areas are bare of vegetation. A few areas are farmed in conjunction with the adjacent smooth areas in cultivation. In such places, however, the surface soil erodes rapidly.

Vernon-Fairview complex.—The Vernon-Fairview complex (pl. 2, *B*) comprises small very closely intermingled bodies of Vernon clay and Fairview silty clay loam. The areas of Vernon clay consist of a thin slightly developed layer of red clay over the unweathered clays and shale of the "Red Beds" formation. The relief ranges from nearly level to very steep. The nearly level areas have a layer of red clay overwash from the adjacent higher slopes and are broken by drainage channels. The areas of Fairview silty clay loam are almost level, with a slope in the general direction of the run-off from the surrounding areas. The soil consists of reddish-brown or brownish-red silty clay loam over a red clay subsoil, which rests, at a depth of several feet, on the "Red Beds" formation. It has developed from materials washed from adjacent higher lying slopes of Vernon soils.

The Vernon-Fairview complex covers a fairly large total area. Although this land is badly eroded in places, about 85 percent of it is covered with grasses, most of which are nutritious and afford good grazing. The grasses on Vernon clay are chiefly buffalo grass, blue grama, side-oats grama, sand dropseed, and three-awn. Fairview silty clay loam has a thick covering of short grasses, including buffalo grass, blue grama, and some needlegrass. The value of this land for grazing is better than that of rough broken land (Vernon soil material), with which it is associated. Because of its generally eroded and gullied condition and the small size of the cultivable spots, this land is used only for grazing.

Vernon clay, eroded phase.—Vernon clay, eroded phase, consists of smooth areas of Vernon clay that have been denuded of most of their soil covering by erosion. The soil material consists of calcare-



A, Tivoli fine sand, dune phase, held from drifting by coarse grasses and shrubs, principally sand sage and sumac. *B*, Gullied Vernon soils developed from "Red Beds" material, on which native cedars are encroaching. *C*, The wide sandy bed of the Cimarron River, which is exposed the greater part of the year and is bordered by shifting sand designated as riverwash.

ous red clay, several inches thick, resting on red clay or shale of the unweathered "Red Beds" formation.

Most of this soil is developed in the northwestern and north-central parts of the county. In areas lying below and adjacent to the bluff-like escarpment, water is received from the small drainageways issuing from the higher plain. Small areas border the escarpment west, southwest, and northwest of Fairview. These eroded areas are barren of vegetation and have no value for farming or grazing. Small scrubby mesquite trees and a few shrubs grow in places.

Rough broken land (Vernon soil material).—Rough broken land (Vernon soil material) consists of land of the "Red Beds" formation, which is so rough, steep, broken, and gullied that it cannot be cultivated. The texture of the fine earth is prevailingly heavy, chiefly clay, but ledges or layers of soft gypsum outcrop in places. Practically all of the soil material has been removed by erosion. The surface is severely gullied, even in the smoother areas. The larger areas occur along and within the steep escarpments, through which deeply incised ravines and gullies reach far back into the higher plain in the western part of the county. Some included areas consist of comparatively smooth exposures of gypsum rock.

Included are small smooth areas of the Weymouth and Vernon soils which could not be shown separately on the map. These and other areas, in which thin layers of soil have accumulated, support a moderate growth of nutritious grasses that afford some pasturage.

Coarse grasses grow in places, together with some small mesquite trees, sumac, yucca, and other shrubs. The more nutritious grasses on some of the smoother areas and in the narrow valleys are chiefly grama and buffalo grass. Although the pasturage is scant in many places, the land, as a whole, is used successfully for grazing range livestock, and local ranchers report that it normally supports about 1 animal to each 24 acres. The rough land affords good protection in winter and some year-round grazing.

Rough broken land (Quinlan soil material).—Rough broken land (Quinlan soil material) is similar in relief and most other features to rough broken land (Vernon soil material). It differs from that land chiefly in that the underlying "Red Beds" formation is sandy, friable, and permeable, in contrast to the heavy clayey character of the "Red Beds" formation underlying the Vernon soil material. Narrow very deep ravines and gullies are cut into the red sandy material, and most of the land is very steeply sloping. Included small smooth areas, not shown separately, are soils of the Quinlan series.

This land occurs chiefly in the southwestern part of the county. It supports a growth of coarse grasses, largely of *Andropogon* species, and shrubs, such as sand sage, yucca, poison-ivy, buckbrush, sumac (two species), wild grape, and wild plum, and, in places, a few prickly pear and cacti. A few trees grow in and along the sides of the ravines. These are chiefly cedar, bur oak, blackjack oak, elm, hackberry, dogwood, gum elastic, or chittamwood, cottonwood, and willow.

All the land is used for grazing cattle, for which purpose it probably is equal to, or slightly better than, rough broken land (Vernon soil material). The many small springs in the valleys provide an additional favorable condition for the grazing of range livestock.

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Carwile clay.—The 6-inch surface layer of Carwile clay is very dark grayish-brown or dark-gray structureless clay. This material grades into an 8-inch layer of brown heavy clay loam or clay, spotted with yellowish brown. Below this and continuing to a depth of 22 inches is light-yellow fine sand, which is underlain by dingy-gray or mottled gray and yellow fine sandy loam. In most places the surface soil is free of calcium carbonate, but in some places the subsoil contains concretions of this material, and in a few places these concretions lie only 15 inches beneath the surface. The principal variations in areas of this soil are slight textural differences in the lower part of the subsoil.

Carwile clay occupies poorly drained basinlike depressions in the uplands throughout the sand-hill section. The areas are not large and have no natural drainage outlets. During periods of heavy rains, water collects in them and disappears slowly through evaporation and seepage. During prolonged droughts, the soil becomes extremely dry and hard, and it cracks badly, causing the vegetation to wither and die.

Almost all of this soil is used for pasture. The native vegetation consists of toadflax (wild flax), ironweed, and, in better drained areas, buffalo grass and blue grama. Most areas of this soil are included in pasture land, although many do not have a high value, even for grazing purposes. Some of the smaller bodies are surrounded by cultivated fields, but they are regarded as wasteland.

Lincoln clay, imperfectly drained phase.—The imperfectly drained phase of Lincoln clay has a dark-gray structureless clay surface soil, about 10 inches thick. Below this material is light-yellow fine sand. The water table is high, and surface drainage is very slow. Most areas of this soil are near the river channels, and during periods of high water they are inundated by backwash from the river. The soil materials in all layers are, for the most part, calcareous.

This soil occupies a few scattered bodies on the flood plains of the North Canadian and Cimarron Rivers. Narrow strips of light-textured Lincoln soils adjacent to the channels of these rivers are included on the map. In these latter places the soils are subject to removal and deposition of variously textured material at each freshet. In many places the surface of the land is ridged or billowed by action of the water.

Grasses on this soil include big bluestem, wild-rye, and redtop, which furnish good pasturage along the North Canadian River. The areas along the Cimarron River receive heavier deposits of clay and are more sparsely grassed than are those along the North Canadian River.

Probably less than 10 percent of this soil is cultivated. Although fairly good yields of grain sorghums are obtained, the uncertainty of flooding prohibits the general use of the land for crops. In some areas in the North Canadian River bottom land the native grasses yield from 1 to 2 tons of hay an acre.

Lincoln clay, saline phase.—The 5-inch surface layer of the saline phase of Lincoln clay is light-gray or light brownish-gray structureless calcareous clay, which is underlain by loose light-yellow or gray fine sand. Areas of this soil are poorly drained and have a high water table. The subsoil is saturated with water high in soluble salts, and, with the movement of water to the surface and its subse-

quent evaporation, an almost white powdery incrustation of salt forms on the surface.

Lincoln clay, saline phase, is very inextensive. It is developed only on the bottom land of the Cimarron River. The largest area is northwest of Cheyenne Valley School. The highly saline condition of the soil prohibits the growth of any except salt-tolerant plants, and more than 50 percent of the land is bare of vegetation. Saltgrass and other salt-resistant plants afford very scant grazing. The position of this saline soil is low, the surface is flat or almost level, and drainage is poor. Included in mapping are very small spots of sandy soils.

Yahola loamy very fine sand.—The 4-inch surface soil of Yahola loamy very fine sand consists of red or light-red calcareous loamy very fine sand. In most places this material is underlain by a 6-inch layer of yellow or reddish-yellow loamy very fine sand, which grades into yellow fine sand.

Areas of this soil are in the Cimarron River flood plains and cover a very small total area. The land, in most places, is almost level, but in numerous areas, the sand has been deposited by wind or water in low ridges, with intervening shallow depressions. The material in the surface soil is variable in texture, but it consists of red sands washed from "Red Beds" formations and deposited over sandy riverbed materials that are chiefly yellow.

Because of its instability, frequency of flooding, shallow and loose porous character, and, in most places, high content of soluble salts, this soil is not farmed, and nearly all of it is used for pasture or for the production of hay. In a few places saltgrass is dominant, but in most places the grass cover consists of big bluestem and other coarse grasses. These grasses afford good grazing and ordinarily yield about 1½ tons of hay an acre. An average of about 8 acres furnishes pasturage for a cow throughout the year.

Riverwash.—Riverwash consists of bare sandy material along the channels of the North Canadian and Cimarron Rivers (pl. 3, *C*). The material for the most part is light-yellow or light grayish-brown loose calcareous fine sand, and it includes a few slight depressions of silt and clay. A few small water-worn gravel of quartz and other rocks are scattered over the surface and throughout the soil mass.

During flood stages of the stream, areas of riverwash are covered to a depth of several feet by swiftly moving water that moves the sand from one place to another. The constant shifting of the material by water, and to some extent by wind when the material is dry, has prevented any growth of vegetation except in places where willows, saltgrass, and a few other plants have obtained a foothold. The land, therefore, has no agricultural value, either for cultivated crops or for grazing. An area of 15.1 square miles is mapped.

PRODUCTIVITY RATINGS

In table 4 the soils of Major County are rated according to their ability to produce the more important crops grown in northwestern Oklahoma and are listed in the order of their relative general productivity.

TABLE 4.—*Productivity rating of soils in Major County, Okla.*

[Based on yields reported for years of moderately favorable conditions]

Soil[1]	Crop productivity index[2] for								
	Corn 50 B	Wheat 25 B	Oats 50 B	Barley 40 B	Grain sorghums 40 B	Sorghums (forage) 4 T	Alfalfa 4 T	Cotton 400 #	Broom-corn 600 #
Pond Creek silt loam	35	80	65	70	50	60	40	40	40
Canadian very fine sandy loam	35	75	55	70	65	70	45	45	45
Reinach very fine sandy loam	30	70	65	70	60	70	45	50	40
Foard very fine sandy loam	35	70	50	60	50	60	50	45	40
Grant very fine sandy loam	35	65	60	65	55	60	35	40	40
Rusk silt loam	30	65	50	60	60	50	30	50	35
Pratt fine sandy loam	35	65	45	55	60	50	20	40	50
Calumet silty clay loam	30	65	50	50	40	45	40	35	25
Carwile fine sandy loam	35	55	45	50	60	60	40	50	50
St. Paul very fine sandy loam	30	60	40	45	50	60	20	35	40
Nash very fine sandy loam	30	50	45	50	45	50	15	20	30
Foard silty clay loam	30	60	40	45	40	45	50	30	30
Reinach fine sandy loam	20	55	45	55	55	45	30	45	45
Rusk silty clay loam	30	55	45	50	45	50	20	45	30
Carmen fine sandy loam	35	50	40	50	60	60	45	45	45
Lincoln silt loam	45	45	25	30	65	65	55	50	45
Yahola very fine sandy loam	30	40	50	60	65	60	45	40	40
Lincoln loamy very fine sand	10	30	50	50	65	55	35	35	40
Enterprise loamy very fine sand	30	50	40	45	55	50	35	25	40
Pratt loamy fine sand	30	50	35	40	55	45	-------	25	45
Canadian loamy fine sand	30	45	35	45	50	60	20	20	45
St. Paul loamy very fine sand	30	50	35	40	55	50	10	15	45
Rusk very fine sandy loam	25	55	40	45	45	50	10	25	25
Yahola fine sandy loam	25	35	40	50	50	60	30	35	40
Reinach silty clay loam	15	45	30	35	30	45	35	35	20
Weymouth very fine sandy loam	30	45	40	40	50	50	10	35	40
Weymouth fine sandy loam	30	40	40	40	50	60	10	30	40
Yahola clay	25	50	35	40	40	50	40	40	35
Fairview silty clay loam	15	40	30	35	30	30	10	25	20
Reinach clay	15	25	30	40	30	45	50	25	20
Reinach loamy fine sand	20	30	30	35	45	50	-------	15	35
Fairview silty clay loam, flat phase	10	35	30	30	25	35	-------	20	15
Tivoli fine sand	20	35	30	35	40	35	-------	15	35
Reinach clay, heavy-subsoil phase	10	25	30	35	25	35	10	20	20
Lincoln very fine sand	10	15	30	25	35	50	40	15	25

Pratt loamy coarse sand	10	10	15	15	25	25	-------	10	20	--
Lincoln clay, imperfectly drained phase	10	-------	10	10	25	25	-------	10	10	
Yahola loamy very fine sand	-------	-------	-------	-------	-------	-------	-------	-------	-------	
Pratt loamy fine sand, dune phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Vernon-Fairview complex	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Vernon very fine sandy loam, broken phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Rough broken land, Vernon soil material	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Rough broken land, Quinlan soil material	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Tivoli fine sand, dune phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Carwile clay	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Lincoln clay, saline phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Vernon clay, eroded phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	--
Riverwash	-------	-------	-------	-------	-------	-------	-------	-------	-------	--

[1] Soils are listed in the approximate order of their general productivity under the better current practices, the most productive

[2] Soil types inherently most productive for the specified crop in the United States are given the index 100. The soils in Major C production in percentages of the standard. Indexes are based on yields in average years.

[3] This classification indicates the comparative general productivity of the soils under the prevailing better current practices. I

[4] This is a general classification given to bring out local comparisons of productivity of the soils of Major County in simple tern etc., as used here are not used on a national basis such as the grade numbers in the preceding column. The drawing of a land-class and necessitates reconsideration of a number of other factors, chief among which is the pattern or distribution of the soils.

The rating compares the productivity of each of the soils for each crop to a standard, namely, 100. This standard index represents the productivity of the more productive soils of significant extent in the United States for that crop. An index of 50 indicates that the soil is about half as productive for the specified crop as is the soil with the standard index. Soils given amendments, such as lime, commercial fertilizers, and irrigation, or unusually productive soils of small extent, have productivity indexes of more than 100 for some crops. The following tabulation sets forth some of the acre yields that have been set up as standards of 100. They represent long-time average yields of crops of satisfactory quality on the better soils without the use of amendments.

Crop:			Crop:		
Corn	bushels	50	Alfalfa	tons	4
Wheat	do	25	Wild hay	do	1
Oats	do	50	Cotton	pounds	400
Barley	do	40	Broomcorn	do	600
Grain sorghums	do	40	Pasture	cow-acre-days [1]	100
Sorghums for forage	tons	4			

[1] Cow-acre-days is a term used to express the carrying capacity of pasture land. As used here, it is the product of the number of animal units carried per acre multiplied by the number of days the animals are grazed without injury to the pasture. For example, the soil able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another soil able to support 1 animal unit per 2 acres for 180 days of the year rates 90. Again, if 4 acres of pasture support 1 animal unit for 100 days the rating is 25.

The productivity indexes in table 4 are based on the yields obtained under the current practices of the better-than-average farmers without irrigation, drainage, terracing, and the use of commercial fertilizers. These figures comprise carefully averaged data obtained from local farmers and are believed to be as accurate as can be secured. The yields that furnish a basis for the estimated indexes refer to those lands that have been under cultivation for a number of years. As a result they have become depleted of their natural fertility, to some extent, by the cultivated crops. Under the usual practices over a given period of years, the productivity of the cultivated land and the carrying capacity of the grazing land decreases, depending on conditions of slope and other general characteristics of the soils.

It is probable that the productivity of much of the land in this county could be nearly doubled by irrigation; and drainage, terracing, and fertilization doubtless would increase productivity in many instances. It will be noted that the indexes of soils are comparatively low. This is largely the result of low rainfall, as compared with that in the section occupied by the standard soil. Some of the better soils of this county, with sufficient rainfall, probably would be given a rating above 100 for some crops.

The soils are listed in the order of their general productivity under the current practices of the better farmers as determined by the weighted average of the crop indexes. The weighted average has been based both on the areal extent of the individual crops and their comparative total value.

Because of the marked differences in the suitabilities and uses of the soils of different textures of both the uplands and bottoms for the common crops, no uniform set of weightings of crop indexes was established to determine the general productivity grades of all the soil types. Instead, separate weightings of crop indexes were set up for each of five general soil conditions as follows, in table 5.

TABLE 5.—*Weightings of crop-productivity indexes for five general soil conditions in Major County, Okla.*

Crop	Moderately heavy and heavy soils of the uplands	Soils with sandy surface soils and moderately heavy subsoils	Sandy soils of the uplands	Soils of the bottom lands	Soils largely limited to grazing
Corn		2	5	10	
Wheat	70	60	30	20	
Oats	5	2			
Barley	5			3	
Grain sorghums	5	10	15	15	
Cotton	3	10	20	10	
Broomcorn	1	1	5	2	
Sorghums for forage	5	10	20	20	
Alfalfa	1			5	
Wild hay				5	
Pasture	5	5	5	10	25
Total	100	100	100	100	25

Since the importance and suitability of certain soils for particular crops in this county cannot be shown altogether satisfactorily by this scheme of weighting, certain modifications in the general rank of the soils were made according to personal judgment.

In addition to listing the soils in the order of their general productivity according to prevailing farming practices, productivity grade numbers are assigned in the column, "General productivity grade" (table 4). These also are based on the weighted average of the crop indexes. If the weighted average falls between 90 and 100, the soil type is assigned a grade of 1; if the weighted average falls between 80 and 90, a grade of 2 is given, etc. The column, "Land classification," summarizes in simple language and compares on a national basis the principal aspects of productivity and use of each soil.

It is to be remembered that soil types do not carry necessarily the same indexes for similar crops from county to county. Systems of management may account for some differences, whereas correlations in soil classification may be responsible for others. Small differences in climatic conditions may affect crop production much more markedly than soil characteristics, or slight modifications of soil characteristics may produce changes in productivity that are not equally influential in soil classification. Thus, Reinach silty clay loam in Major County receives lower crop indexes than it does in Garfield County because it is heavier and more droughty. Again, Nash very fine sandy loam is developed more deeply in Major County and hence is more productive than in Garfield County.

Productivity tables do not present the relative roles, which soil types, because of their extent and the pattern of distribution, play in the agriculture of the county. Tables 4 and 5 give a characterization to the productivity of individual soil types. They cannot picture the total quantitative production of crops by soil areas without the additional knowledge of the acreage of the individual soil types devoted to each specified crop.

Economic considerations have played no part in determining the productivity indexes, so they cannot be interpreted into land values except in a very general way. Distance to market, relative prices of farm products, and other factors influence the value of land.

RECOMMENDATIONS FOR THE MANAGEMENT OF THE SOILS OF MAJOR COUNTY

The conservation of rainfall by contour farming is the most important factor in the successful management of a large proportion of the cultivated land in Major County, because crop production usually is limited on most of the soils by the quantity of water that penetrates the subsurface layers when rains occur. As sorghums and small grain are planted on a large part of the cropland and since these crops cannot be used to advantage in a rotation system of cropping, the average farmer produces small grain, chiefly winter wheat, on the most productive land and sorghums on the sandy land or shallower soils.

Because of the limited rainfall and the low potential fertility of the soils, many of the sandy soils produce low yields, and the opportunity to improve their productive capacity is limited. Cowpeas are the only legumes which make very much growth on these soils, and their production depends on weather conditions in the summer and early fall. Wind erosion is a serious problem in places where the organic matter has been reduced as a result of cultivation and no protective cover is left on the land during the winter and early spring. Many fields have been seriously damaged by wind erosion and should be returned to pasture. Strip cropping has not been utilized extensively, but it is one method that will reduce the destructive effect of wind erosion on the sandy land. Under average conditions, strips planted in an east-west direction are preferable to strips planted on a contour. The farm income from the sandy soils is low, regardless of the type of farming followed.

The combined effect of soil erosion and tillage has proved detrimental to the potential productivity of many soils in this county. Summer rainfall in this area is torrential in character, and soil losses by water erosion have been severe, because the water is not retained on the land by proper tillage methods and other soil-conservation practices. A study of the content of organic matter, total nitrogen, and phosphorus in 13 samples of soil collected from grassland or pasture, and a similar number of samples collected from cultivated fields adjacent to these virgin areas, indicates that a gradual decrease in the content of nitrogen and organic matter of these soils has taken place. These results are given in table 6.

[6] By H. J. Harper, professor of soils, Agronomy Department, Oklahoma Agricultural and Mechanical College.

TABLE 6.—*Losses of plant nutrients in soils in Major County, Okla., as a result of cultivation*

[Average of 13 comparisons]

Condition of soil	Nitrogen [1]	Phosphorus [1]	Organic matter [1]
	Pounds	*Pounds*	*Pounds*
Virgin	2,470	698	47,200
Cropped	1,995	650	33,800
Loss through cultivation	475	48	13,400

[1] Pounds per acre in soil 6⅔ inches deep.

According to the analyses given in table 6, more than 28 percent of the total organic matter in these soils has disappeared as a result of cultivation and loss by erosion. It is probable that an extensive type of agriculture always will be followed, because, due to the climate, the level of crop production is low. Legumes require more moisture to produce a pound of dry matter than do grain sorghums or small grains, and, in order that the legume may have a good effect on the following crop, the rainfall must be favorable. The small number of experiments that have been conducted indicate that soil improvement as a result of the growth of legumes has not been profitable, considering the total crop yield which would have been obtained if the land planted to the legume had been planted to wheat. Lack of inoculation of legumes grown in comparatively dry soil may be the reason that these crops do not improve the crop-producing capacity of the land on which they are grown. More nodules occur on the roots of winter legumes or legumes which grow in early spring or late fall than on summer legumes, such as mung beans, cowpeas, or soybeans.

Two legumes that can be grown on the fine-textured soils when moisture conditions are favorable are Austrian Winter peas and annual white sweetclover. These crops may be used for forage or may be plowed under, in order to improve the physical condition and increase the available nitrogen content of the soil. Since the summer rainfall is more abundant than the fall and winter rainfall, it may be that annual white sweetclover will prove superior to Austrian Winter peas, because it grows during a period when moisture and climatic conditions generally are favorable for plant development, and the crop matures before the hot dry weather of summer.

A study of the plant-nutrient content of 11 samples of surface soil and subsurface soil, taken from cultivated areas of land in different parts of the county, indicates that the total nitrogen and organic-matter content of most of these soils is low. The results of these partial analyses are shown in table 7.

TABLE 7.—*Partial chemical composition of samples of surface soils and subsurface soils of 11 soils of the uplands, from different parts of Major County, Okla.*

Soil type and sample No.	Location	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
			Percent	*Percent*	*Percent*	*Parts per million*
Tivoli fine sand:						
2006 [1]	NE¼ sec. 18, T. 22 N., R. 10 W.	7.0	0.016	0.65	0.010	12
2007 [2]		7.0	.030	.83	.012	4
Tivoli fine sand, dune phase:						
1998 [1]	SW¼ sec. 12, T. 20 N., R. 11 W.	7.6	.020	.92	.011	24
1999 [2]		7.0	.028	.69	.011	10
Fairview silty clay loam, flat phase:						
1996 [1]	SW¼ sec. 20, T. 21 N., R. 11 W.	8.6	.097	1.49	.053	320
1997 [2]		8.6	.097	.74	.058	300
Rusk very fine sandy loam:						
2008 [1]	NE¼ sec. 25, T. 22 N., R. 14 W.	8.3	.098	1.91	.035	150
2009 [2]		8.1	.043	.70	.022	90
Rusk very fine sandy loam:						
2010 [1]	NE¼ sec. 23, T. 23 N., R. 16 W.	7.7	.091	1.89	.045	200
2011 [2]		8.2	.071	1.20	.030	160
Foard silty clay loam:						
2004 [1]	SE¼ sec. 12, T. 22 N., R. 10 W.	6.9	.126	2.10	.043	120
2005 [2]		6.9	.042	1.36	.034	80
Grant very fine sandy loam:						
2002 [1]	SW¼ sec. 12, T. 22 N., R. 9 W.	7.3	.079	1.70	.027	90
2003 [2]		7.5	.081	1.45	.025	60
Pratt loamy fine sand, dune phase:						
2016 [1]	NW¼ sec. 15, T. 20 N., R. 15 W.	7.4	.062	1.60	.041	80
2017 [2]		7.2	.047	1.20	.037	50
Pratt loamy fine sand:						
2000 [1]	NW¼ sec. 28, T. 21 N., R. 9 W.	6.7	.038	.85	.017	32
2001 [2]		-----	.046	.84	.012	10
Reinach loamy fine sand:						
1994 [1]	SW¼ sec. 10, T. 20 N., R. 12 W.	6.8	.096	1.19	.034	120
1995 [2]		7.3	.089	1.48	.029	110
St. Paul very fine sandy loam:						
2012 [1]	NW¼ sec. 25, T. 22 N., R. 16 W.	7.0	.039	1.03	.018	60
2013 [2]		7.5	.046	1.03	.034	35

[1] Surface soil.
[2] Subsurface soil.

Nitrogen fixation by soil organisms other than legume bacteria occurs in the majority of the soils in this county. These organisms are most active in soils that are high in available calcium, phosphorus, and potassium, but no data are available on the actual quantity of nitrogen added to the soil from this source. The total phosphorus content of the sandy soils is low, but the phosphorus content of the fine-textured soils is equal to or above the general average for the State. The availability of the prosphorus in most of the soils that have been analyzed is high, and it is not likely that phosphorus fertilization will be needed to increase crop yields on many of these soils for a long time. Tests on the readily available phosphorus in 101 samples of surface soil proved the following: 56 samples were very high in readily available phosphorus, as determined by dilute acid extraction or leaching; 23 samples were high; 11 samples medium; 8 samples low; and 3 samples very low in this important plant nutrient. Low availability of phosphorus is closely associated with Enterprise loamy very fine sand and Pratt loamy fine sand.

Only a few of the soils are acid. One hundred and twenty-five samples of soil collected from various parts of the county have been tested for soil acidity and show very definitely that soil development has occurred under the influence of scant rainfall. Of the 125 samples, 58 samples of surface soil contain free calcium carbonate; 36 contain enough calcium and other bases to give a neutral reaction favorable for the growth of sweetclover and other lime-loving crops; 13 are slightly acid; 8 are slightly acid+; 7 are medium acid; 2 are acid+; and only 1 is strongly acid. Although the surface soil may be acid, nonacid layers are generally present within the zone of root development. This is an important factor in determining the need for an application of ground limestone, which is frequently unnecessary when slightly acid surface soils have an abundant supply of available calcium in the subsurface layers.

In some areas natural erosion has been sufficiently rapid to remove the surface layers of the soil as rapidly as leaching occurs, consequently the surface soils are not acid because in this county the subsurface soils usually contain basic material that has not been removed by percolating water. In some of the sandier areas more leaching has occurred because the texture provides a more favorable condition for the penetration of water during periods of abundant rainfall. Lime may be needed in order to obtain a satisfactory growth of sweetclover on some of the soils.

Results concerning the effect of tillage on the production of wheat at the Woodward field station (*2*) indicate that early plowing increased the yield of wheat 6½ bushels an acre over a 12-year period on Pratt loamy fine sand. Summer fallow gave the highest average yield, but the greatest total yield for equal areas of land was obtained when wheat was planted every year on land which was plowed as soon as possible after the previous crop was harvested. Cowpeas in a cropping system with wheat produced about the same effect as grain sorghum, since both crops remove subsoil moisture, and this is generally a limiting factor in the production of wheat.

The proper management of pasture land is largely a matter of conservation of moisture and controlled grazing. Shallow lister furrows constructed on a contour on gentle slopes will retain a high percentage of the run-off water under average conditions. On overgrazed land this treatment is important, in order to stimulate the growth of grass and hasten the development of a protective cover. Contour furrows are limited to comparatively smooth topography and to slopes of less than 10 percent. There are some areas in which water should be diverted from the steeper slopes or from drainage channels to gently sloping areas. Loss of water by run-off usually means loss of potential income; consequently every farmer should develop a plan for the conservation of water on the land that he operates.

Data on the chemical composition of 29 typical soil profiles collected from virgin and cropped areas are given in table 8.

TABLE 8.—*Partial chemical composition of soils in Major County, Okla.*

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Percent*	*Percent*	*Percent*	*Parts per million*
SANDY SOILS WITH SANDY SUBSOILS							
Canadian loamy fine sand:[1]							
4955	SW¼ sec. 24, T. 20 N., R. 16 W.	0 - 6	7.6	0.092	1.70	0.033	40
4956		6 -15	7.7	.061	1.40	.031	40
4957		15 -32	8.0	.020	.45	.019	20
Tivoli fine sand:							
5069	Sec. 15, T. 20 N., R. 16 W.	0 - 3	7.1	.040	1.05	.020	18
5070		3 -15	7.4	.016	.55	.013	17
5071		15 -40	7.4	.011	.25	.004	8
5072		40+	7.5	.017	.15	.008	9
Tivoli fine sand, dune phase:							
5039	NE¼SE¼ sec. 8, T. 20 N., R. 15 W.	0 - 3	6.6	.046	1.36	.008	15
5040		3 -12	5.8	.007	.21	.004	3
5041		12 -34	6.2	.007	.24	.004	2
5042		34 -72	5.6	.004	.21	.003	2
5043		72+	6.9	.004	.14	.003	3
Reinach loamy fine sand:							
3906	NW¼ SW¼ sec. 9, T. 20 N., R. 12 W.	0 - 3½	6.9	.061	1.30	.016	52
3907		3½-18	7.3	.026	.55	.013	20
3908		18 -40	7.3	.029	.34	.017	16
SANDY SOILS WITH MODERATELY FINE TEXTURED SUBSOILS							
Canadian very fine sandy loam:[1]							
4980	NW¼NW¼ sec. 33, T. 20 N., R. 16 W.	0 - 6	7.6	0.069	1.09	0.031	104
4981		6 -14	7.4	.067	1.37	.031	80
4982		14 -24	7.6	.059	1.05	.029	88
4983		24 -42	7.8	.025	.85	.026	72
4984		42 -52	7.9	.023	.55	.026	48
Carwile fine sandy loam:							
3911	NW¼NE¼ sec. 22, T. 20 N., R. 15 W.	0 - 6	6.1	.114	1.14	.027	48
3912		6 -14	6.4	.057	.77	.016	16
3913		14 -36	6.7	.014	.20	.013	6
3914		36 -85	6.8	.012	.05	.020	8
Rusk very fine sandy loam:							
3890	SW¼SW¼ sec. 4, T. 22 N., R. 14 W.	0 - 3½	8.7	.135	2.93	.025	160
3891		3½-12	8.7	.079	1.80	.047	112
3892		12 -18	8.0	.065	1.40	.021	80
3893		18 -22	7.4	.048	.78	.023	96
3894		22 -36	8.2	.029	.45	.022	120
3895		36 -50	8.6	.019	.18	.023	160
Grant very fine sandy loam:							
4988	NE¼ sec. 10, T. 22 N., R. 9 W.	0 - 2	7.3	.146	5.20	.025	34
4989		2 - 4	5.9	.118	2.54	.018	14
4990		4 -16	5.7	.110	1.90	.015	9
4991		16 -28	6.0	.127	1.53	.016	4
4992		28 -64	6.8	.037	.23	.012	20
Nash very fine sandy loam:							
5034	NW¼SW¼ sec. 11, T. 22 N., R. 9 W.	0 - 2	7.1	.144	1.94	.033	56
5035		2 - 6	7.2	.144	2.05	.029	48
5036		6 -16	7.2	.075	1.10	.029	56
5037		16+	8.0	.031	.45	.041	88
Pond Creek silt loam:							
4961	NE¼NE¼ sec. 36, T. 23 N., R. 9 W.	0 - 1½	6.1	.021	4.45	.037	34
4962		1½- 6	6.0	.111	3.05	.034	22
4963		6 -12	5.6	.087	1.60	.024	16
4964		12 -22	5.6	.089	1.15	.018	16
4965		22 -36	6.3	.056	.79	.027	64
4966		36 -58	7.0	.065	.76	.027	48
Reinach fine sandy loam:[1]							
3915	NW¼NE¼ sec. 11, T. 20 N., R. 12 W.	0 - 7	7.1	.041	1.00	.013	48
3916		7 -15	7.5	.038	.49	.025	48
3917		15 -28	8.0	.029	.15	.031	52
3918		28 -40	8.4	.019	.48	.021	96
Reinach fine sandy loam:[1]							
3934	SW¼SE¼ sec. 9, T. 20 N., R. 12 W.	0 - 5	7.7	.014	.48	.027	24
3935		5 -15	7.1	.019	.38	.035	20
3936		15 -40	7.3	.023	.23	.033	20

[1] Samples collected from cultivated land.

TABLE 8.—*Partial chemical composition of soils in Major County, Okla.*—Contd.

SANDY SOILS WITH MODERATELY FINE TEXTURED SUBSOILS—Continued

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Percent*	*Percent*	*Percent*	*Parts per million*
Reinach very fine sandy loam:[1]							
3925	SE¼ sec. 18, T. 20 N., R. 11 W.	0 - 9	8.0	0.076	1.21	0.021	120
3926		9 -14	8.1	.071	.93	.024	88
3927		14 -26	8.5	.019	.49	.017	104
3928		26 -42	8.7	.025	.30	.022	128
3929		42 -48	8.6	.027	.32	.026	160
Reinach very fine sandy loam:							
5046	NE¼NW¼ sec. 15, T. 20 N., R. 12 W.	0 - 4	6.4	.041	2.65	.034	52
5047		4 -18	6.3	.091	1.85	.024	32
5048		18 -24	6.1	.063	1.16	.022	32
5049		24 -36	6.5	.054	.72	.019	36
5050		36 -54	7.0	.016	.42	.032	72
5051		54 -60+	7.3	.018	.20	.023	48
St. Paul very fine sandy loam:							
5054	NW¼NE¼ sec. 16, T. 21 N., R. 15 W.	0 - 1½	6.9	.181	3.75	.045	64
5055		1½- 4	7.1	.134	2.22	.020	48
5056		4 -19	6.8	.083	1.59	.017	52
5057		19 -30	7.0	.067	1.29	.018	56
5058		30 -42	7.5	.052	.69	.017	80
5059		42 -57	8.1	.030	.50	.030	32
Weymouth very fine sandy loam:							
3940	SE¼ sec. 30, T. 21 N., R. 13 W.	0 - 3	7.9	.133	2.59	.026	88
3941		3 -12	7.6	.087	1.80	.025	72
3942		12 -19	7.6	.075	1.13	.025	68
3943		19 -31	8.6	.080	1.23	.021	12
Weymouth very fine sandy loam:							
4996	NE¼NE¼ sec. 7, T. 21 N., R. 15 W.	0 - 1½	6.8	.099	2.05	.023	28
4997		1½- 5	6.6	.057	1.40	.025	20
4998		5 -12	6.4	.061	1.51	.020	18
4999		12 -30	6.6	.035	.49	.015	14
5000		30+	6.8	.039	.63	.026	40

SOILS WITH FINE-TEXTURED SURFACE AND SUBSURFACE SOILS

Calumet silty clay loam:							
3879	SE¼ sec. 11, T. 20 N., R. 12 W.	0 - 1	6.4	0.324	4.65	0.033	104
3880		1 - 2½	6.4	.260	3.10	.041	176
3881		2½- 4½	6.6	.190	2.13	.034	176
3882		4½- 8	8.1	.131	1.75	.028	104
3883		8 -24	8.1	.084	1.20	.034	104
3884		24 -33	8.1	.047	.94	.022	112
3885		33 -45	8.2	.043	.88	.027	136
Fairview silty clay loam, flat phase:[1]							
3937	SE¼ sec. 4, T. 20 N., R. 12 W.	0 - 2½	7.5	.109	1.87	.029	80
3938		2½- 9	7.9	.086	1.30	.026	56
3939		9 -20+	8.5	.062	.90	.024	48
Rusk silty clay loam:							
5026	SW¼ sec. 16, T. 20 N., R. 12 W.	0 - 2	6.8	.095	2.90	.045	64
5027		2 - 8	7.0	.100	1.30	.041	48
5028		8 -14	6.8	.096	1.00	.039	32
5029		14 -25	7.0	.073	1.45	.034	32
5030		25 -60	7.7	.043	.30	.032	52
Foard silty clay loam:							
5011	SW¼SW¼ sec. 16, T. 22 N., R. 9 W.	0 - 2	6.2	.191	4.86	.039	56
5012		2 - 4	5.8	.140	3.55	.037	48
5013		4 - 9	6.6	.119	2.65	.034	48
5014		9 -15	6.5	.092	2.13	.029	56
5015		15 -30	7.4	.044	1.15	.029	64
5016		30 -37	7.6	.021	1.35	.019	60
5017		37 -75	7.9	.021	.50	.019	2
Rusk silt loam:							
5003	SE¼NW¼ sec. 30, T. 21 N., R. 12 W.	0 - 2	6.4	.189	4.14	.048	96
5004		2 - 5	6.8	.158	3.40	.047	88
5005		5 -24	6.9	.097	2.00	.047	56
5006		24 -38	7.0	.074	1.72	.042	56
5007		38 -70	7.6	.045	.82	.048	112

[1] Samples collected from cultivated land.

TABLE 8.—*Partial chemical composition of soils in Major County, Okla.*—Contd.

SOILS WITH FINE-TEXTURED SURFACE AND SUBSURFACE SOILS—Continued

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Percent*	*Percent*	*Percent*	*Parts per million*
Reinach clay, heavy-subsoil phase:[1]							
3947	NW¼NW¼ sec. 18, T. 21 N., R. 12 W.	0 - 5	8.3	0.085	1.45	0.035	208
3948		5 -15	8.4	.052	.55	.045	288
Calumet silty clay loam:							
3896	NE¼ sec. 18, T. 21 N., R. 12 W.	0 - 3	8.1	.095	1.55	.020	224
3897		3 -11	8.4	.048	.58	.027	320
3898		11 -23	.5	.054	.63	.025	192
3899		23 -34	8.7	.056	1.06	.018	192
3900		34 -48	8.6	.062	.93	.023	144
Rusk silt loam:[1]							
3919	SW¼SE¼ sec. 14, T. 20 N., R. 12 W.	0 - 5	7.3	.068	.80	.020	120
3920		5 -14	7.7	.046	.85	.027	80
3921		14 -18	7.9	.057	.60	.026	64
3922		18 -28	8.1	.046	.40	.020	80
3923		28 -36	8.6	.019	.37	.022	96
3924		36 -42	8.7	.019	.19	.021	160
Calumet silty clay loam:[1]							
3930	SW¼SW¼ sec. 24, T. 20 N., R. 12 W.	0 - 5½	7.6	.106	.95	.013	96
3931		5½-15	7.6	.076	1.26	.025	80
3932		15 -25	8.6	.067	.48	.022	88
3933		25 -40	8.6	.019	.35	.020	80
SOILS OF THE BOTTOM LANDS							
Lincoln silt loam:							
4972	SE¼NE¼ sec. 20, T. 20 N., R. 16 W.	0 - 6	8.1	0.090	1.25	0.032	136
4973		6 -15	8.2	.076	1.33	.035	128
4974		15 -20	8.2	.056	1.15	.028	12
4975		20 -28	8.6	.035	.80	.026	48
4976		28 -40	8.4	.019	.45	.020	48
4977		40+	8.6	.019	.35	.026	120
Lincoln loamy very fine sand:							
5063	SE¼SE¼ sec. 17, T. 20 N., R. 16 W.	0 - 5	7.9	.119	2.20	.027	32
5064		5 -15	8.4	.017	.60	.009	20
5065		15 -30	8.5	.013	.20	.006	12
5066		30+	8.4	.009	.20	.009	6
Yahola clay:							
3909	NE¼NW¼ sec. 11, T. 21 N., R. 13 W.	0 - 6	8.2	.181	3.14	.034	176
3910		6 -20	8.3	.074	.95	.025	272

[1] Samples collected from cultivated land.

These results support some of the suggestions that have been made concerning the analyses given in tables 6 and 7. Tivoli fine sand, dune phase, has been more thoroughly leached than the other sandy soils analyzed. This soil is very deficient in total nitrogen, organic matter, and total and readily available phosphorus. Carwile fine sandy loam, which occurs in depressions in many places surrounded by Pratt or Tivoli soils, has a leached acid surface soil, but this sample does not show a serious deficiency of organic matter, nitrogen, or phosphorus. Pond Creek silt loam, which was collected near the eastern edge of the county, occurs on topography favorable for the retention of rainfall, and its profile has been leached sufficiently so that sweetclover will not make a maximum growth without the addition of finely ground limestone to neutralize the acidity. The virgin profile of Grant very fine sandy loam shows an accumulation of lime in the topmost 2 inches and a medium acid condition in the subsurface layers. The organic-matter content of sandy soils with friable subsoils does

not decrease so rapidly with depth as in the fine-textured soils with fine-textured subsoils, especially where the topography of these soil types is similar. Some of the soil profiles listed in table 8 were taken from cropped areas, and these are indicated in the table. It is probable that the results from cropped land give a better indication of the potential productivity of the average soil under present conditions than do those for samples collected from virgin areas.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of the environment acting upon the soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the relief, or lay of the land, which determines the local or internal climate of the soil, its drainage, moisture content, aeration, and susceptibility to erosion; (4) the biological forces acting upon the soil material, that is, the plants and animals living on and in it; and (5) the length of time the climatic and biological forces have acted on the soil material.

Major County lies in a zone of transition between the western plains, where the normal soils reflect the environment of pedocalic soil development, and the more easterly lying prairies, where the higher rainfall of the humid section causes the more thorough leaching that is an important factor in soil development in the pedalferic environment.

Because of the great difference in rate of permeability of soil parent materials in several large areas throughout this and adjoining counties in this transitional zone between the pedocalic and pedalferic soil regions, soil characteristics representative of each of these great soil regions extend both eastward and westward beyond the true zonal areas. Soils developed from loose sandy permeable materials, therefore, have not everywhere the accumulation of calcium carbonate, which characterizes normal pedocalic soils. The excessive leaching allowed by the permeable soil parent materials here produces a pedalferic development with a somewhat lower rainfall than would be required to produce equal leaching with greater rainfall on less permeable soil materials farther east in the humid region. On the other hand, some of the smooth heavier soils developed from heavy soil parent materials have a fairly well defined layer of accumulated calcium carbonate, indicating a pedocalic development, and they extend eastward from the county well into the zone of pedalferic soil development. This is probably due to the dense subsoil which prevents ready permeability and leaching through the soil. This county is considered to lie within the region of pedocalic soils, although some normal pedalferic soils occur within it.

The soils have been developed from parent materials ranging from deep loose sands to sandy clay, clay, and shale. The heavier materials, as well as some sandy materials, are of the Permian "Red Beds" formations, and some loose deep sands are of Quaternary and Tertiary ages, representing deposits spread deeply over the "Red Beds." Comparatively small areas are of soils comprising soil materials deposited as alluvium. Soil parent materials are both calcareous and noncalcareous.

The factors of environment which aid in the development of soils from geological formations are climate, native vegetation, relief, and drainage. The soils of this county have developed in a fairly dry, moderately warm climate, under cover of short grasses and coarse bunchgrasses, on surfaces that range from very smooth to very steep. Only on the smooth areas of moderately heavy parent materials and under a heavy growth of short grasses are the normal mature soils developed, and these do not constitute a very large proportion of the land area of the county. Based on the degree of development, the soils belong to four general groups: Normal maturely developed soils (*5*), soils of very slight development, soils of intermediate stages of development, and soils of recent alluvium of the flood plains.

The normal maturely developed soils occupy less than one-fifth of the county. They are developed on smooth surfaces from rather permeable materials of the "Red Beds" and are chiefly of the St. Paul, Rusk, Fairview, Pond Creek, and Grant series. Soils which are of advanced maturity but do not reflect truly the normal regional environment are claypan soils of the Foard and Calumet series. These soils have dense claypan subsoils and are, in places, of solonetz-like character. In places the flat surfaces have a microrelief of shallow depressions about 8 feet in diameter. These depressions probably have been formed by the differential erosion of the light surface layers lying on the hard claypan horizon (*4*). Soils of intermediate maturity or comparatively youthful development are of the Weymouth, Nash, Pratt, Reinach, Canadian, and Enterprise series. The very youthful upland soils are those of the Vernon and Quinlan series and have developed on steep to moderate slopes from "Red Beds" materials. The soils from recent alluvium on the bottom lands belong to the Lincoln and Yahola series.

The normal soil profile of the county is probably best represented by St. Paul very fine sandy loam, which has developed from sandy beds or sandstone on smooth areas of the Permian "Red Beds" under a short-grass cover in the subhumid climatic region. Following is a description of a profile of this soil, as observed on a smooth upland divide about one-fourth mile east of the northwest corner of sec. 10, T. 21 N., R. 15 W.:

1. 0 to 1½ inches, reddish-brown or dark reddish-brown friable very fine sandy loam, which forms a structureless dustlike layer. The material is not calcareous.
2. 1½ to 4 inches, reddish-brown or dark reddish-brown noncalcareous mellow friable structureless very fine sandy loam containing a few worm borings and casts. The color changes to a very slightly lighter brown when the material is crushed.
3. 4 to 19 inches, dark reddish-brown friable silt loam or heavy very fine sandy loam. The material is granular and crumbly. When wet, the color is somewhat red. When dry, the material in this layer contracts into prismatic blocks, from 4 to 6 inches in diameter, with flat horizontal breakage. It is not calcareous.
4. 19 to 30 inches, brownish-red noncalcareous friable silt loam or silty clay loam similar to the material in the layer above, except that it is not granular.
5. 30 to 42 inches, red friable crumbly heavy silt loam or clay loam, which is slightly redder when crushed. This is the heaviest and densest layer in the profile, but its increased compaction is not noticeable, except by comparison with other layers. The material is not calcareous.

6. 42 to 57 inches, red or light-red heavy very fine sandy loam, with a high content of calcium carbonate, which occurs in disseminated form and as hard concretions and soft coatings on the surfaces of clods, cracks, and seams. This is the layer in which calcium carbonate accumulates.
7. 57 inches +, red calcareous very fine sandy loam parent material of the "Red Beds" formation.

In the northeastern part of the county two soils—Pond Creek silt loam and Grant very fine sandy loam—are representative of soils developed beneath a grass cover on smooth surfaces from the Permian "Red Beds" parent materials but, as a rule, showing little or no developed accumulation of calcium carbonate in the soil profile. The structure, permeability, and color of these soils are not greatly different from those features of the St. Paul soils, but these soils occur more extensively in more eastern areas under the pedalferic influence and are considered transitional representatives from the true Prairie soils of the humid region. The profile of Pond Creek silt loam is as follows:

1. 0 to 12 inches, brown or dark-brown noncalcareous crumbly silt loam. The material is friable when moist and does not pack tightly on drying.
2. 12 to 24 inches, generally dark-brown or dark reddish-brown granular friable silty clay loam or light clay, which is not calcareous. Insect casts are numerous.
3. 24 to 36 inches, reddish-brown crumbly noncalcareous prismatic clay.
4. 36 inches +, red or reddish-brown heavy crumbly clay, which generally is not calcareous, although it is slightly calcareous in places. It is somewhat sandy below a depth of 5 feet.

The Grant soils have permeable crumbly but moderately heavy subsoils similar to those of the Pond Creek soils, but the soil material throughout all the layers is more distinctly red and less dark. The surface, as a rule, is more sloping than that of the Pond Creek soils, and the content of organic matter is less.

Foard silty clay loam, which occurs in a number of areas, represents the development on smooth surfaces of a claypan soil from heavy "Red Beds" parent materials, possibly also under the influence of some accumulated salts, in the subhumid climatic area. The profile is as follows:

1. 0 to 8 inches, dark-brown silty clay loam, which is structureless except for slight lamination in the upper part. The material is noncalcareous, friable when moist, and packs tightly to a dense mass on drying in undisturbed situations. It rests abruptly on the layer beneath.
2. 8 to 24 inches, very dark brown or dark grayish-brown noncalcareous dense tough clay. No granulation has developed. The material breaks into large slick-surfaced sharp clods. The transition to the next lower layer is gradual.
3. 24 to 36 inches, brown or grayish-brown heavy clay containing some calcareous concretions. The fine earth also is calcareous in places. This layer is less dense than the overlying layer and is the layer of calcium carbonate accumulation. It grades into the parent material below.
4. 36 inches + reddish-brown calcareous fine sandy clay consisting of partly weathered "Red Beds" materials of clay or shaly clay.

Soils developed from the "Red Beds" formations on moderate slopes are members of the Nash and Weymouth series. These are semimature soils. The Nash soils represent a youthful stage of soil development, which eventually might produce soils of the Grant series, whereas the Weymouth soils seem to constitute a more advanced stage

of the Vernon soils. These soils are brown or reddish brown and have thin layers. The Weymouth soils have a very slight accumulation of calcium carbonate in places, indicating a youthful pedocalic development, whereas the Nash soils are more representative of a youthful Prairie soil subject to the pedalferic influence.

Large bodies of loose deep sandy soils cover a considerable proportion of the county, mainly in the eastern part, in a broad belt bordering the north side of the flood plain of the Cimarron River, and in a wide area occupying most of the southwestern part. These soils have developed from deep sandy beds of loose sand or sandy clay comprising materials of Quaternary and Tertiary ages. Because of the very permeable character of these sandy beds, the soils have been leached rather freely, although in many places calcium carbonate has accumulated in a manner characteristic of the more normally developed pedocalic soils. These soils, which belong to the Pratt, Tivoli, Enterprise, Carwile, and Carmen series, have developed under a coarse grass cover. In places the sandy material has been shifted considerably by the wind, giving rise to a billowy or dunelike relief.

The Pratt soils are extensive throughout the western and southwestern parts of Oklahoma. They are deep sandy soils, which are rather productive, considering the large content of siliceous material. As a rule, the deep very sandy soils of the Pratt series have little or no accumulation of calcium carbonate. The fine sandy loam member, however, which has a moderately heavy subsoil, does have this pedocalic characteristic in places, generally in the form of concretions of calcium carbonate throughout the sandy clay subsoil.

The Carwile soils, developed on small smooth areas, surrounded in most places by higher lying areas of Pratt soils, are differentiated from those soils by the presence of rather heavy subsoil horizons of clay or sandy clay. The Carwile soils, for the most part, appear to have formed in areas where both surface and internal drainage are slow, and, in places, concretions of calcium carbonate are accumulated to greater or less extent in a layer ranging from 2 to 3 feet beneath the surface.

The Carmen soils, also associated with very sandy soils, are characterized by the presence of highly calcareous materials, largely in the form of concretions of calcium carbonate throughout the soil. Possibly this is due to a temporarily high water table caused by underflow, over buried calcareous "Red Beds" formations, of excess water leached through deep beds of higher lying loose sands. This probably has produced a seepage effect, leaving on evaporation the large quantity of calcareous materials in the soil layers.

Thin immature red soils developed from the "Red Beds" formations on steep to moderate slopes where erosion is active cover considerable areas. These are of the Vernon and Quinlan series. The soils of these series are similar in color and stage of development but differ in physical characteristics. The Vernon soils are developed on heavy parent materials of the "Red Beds" formations, largely clay, whereas the Quinlan soils are formed on the very sandy and highly permeable "Red Beds" material. This difference is reflected in the subsoils and substrata, which are heavier and more slowly permeable in the Vernon than in the Quinlan soils.

The Enterprise soils include the well-drained permeable reddish-brown soils that have been developed under grass from wind-blown materials transported largely from the western "Red Beds." These soils, although developed under the pedocalic environment, have no well-defined accumulation of calcium carbonate in the profile. They range from slightly acid to slightly alkaline from place to place and in some places are slightly calcareous. These soils are characterized also by the absence of a well-developed texture profile, in that there are no distinct differences in the textures of the surface soil and the subsoil. The topography is undulating to gently rolling, although some areas are billowy and others very smooth. The Enterprise soils are largely in cultivation.

The Tivoli soils are light-colored (grayish-brown or pale reddish-brown) and immature very sandy soils that have been developed under grass from wind-blown materials. They have uniform or nearly uniform texture profiles and are incoherent throughout. Except for the rather small amount in the surface layers, the profile is almost devoid of organic matter. The solum is commonly neutral but may be slightly acid in the upper part and slightly alkaline in the lower. The topography is chiefly undulating to hummocky with dunelike areas, which are separated as a dune phase and which are suitable only for grazing. The Tivoli soils are similar to the Enterprise soils but differ from them in their lighter color, more incoherent character, more billowy relief, and general unsuitability for cultivated crops, although in this county a larger proportion of typical Tivoli fine sand is cultivated than of Enterprise loamy very fine sand, the only Enterprise soil mapped.

Large and small bodies of smooth-lying soils scattered throughout the county are developed from either thick or thin accumulations of water-laid materials, both as outwash plains from higher levels and from alluvium on flood plains, which later, as the streams cut more deeply, were left as high terraces and no longer are subject to overflow and deposition of transported sediments. These parent materials of fine earth, ranging in texture from sand to clay, are, for the most part, calcareous and have undergone the processes of soil development for a long time. The characteristics of the resulting soils reflect, as a rule, the pedocalic environment. These soils are members of the Rusk, Fairview, Calumet, Reinach, and Canadian series.

The Rusk and Fairview soils are formed from moderately heavy materials washed, for the most part, from local higher lying areas of "Red Beds," and soils of the "Red Beds" are intermingled to some extent with materials of other plains soils. The soils of these two series are somewhat similar, but the Rusk soils are darker and deeper than the Fairview, and the latter soils are, as a rule, redder and more calcareous. Following is a description of a profile of Fairview silty clay loam, flat phase, situated about one-sixth mile west of the southeast corner of sec. 4, T. 20 N., R. 12 W.:

1. 0 to 2 inches, reddish-brown noncalcareous heavy silt loam or very fine sandy loam. The material breaks horizontally or has a slight platy structure.
2. 2 to 6 inches, dark reddish-brown silty clay loam, with an irregular fragmental structure. Most of the brown color is in the colloidal material that coats the structure particles. There are a few concretions of calcium carbonate.

3. 6 to 12 inches, reddish-brown calcareous heavy silty clay loam with a nut or fragmental structure and containing sharp angular particles.
4. 12 to 18 inches, brownish-red clay without well-defined structure, in which calcium carbonate is abundant in disseminated form as well as in soft and hard concretions.
5. 18 to 50 inches, friable red clay, which contains calcium carbonate in disseminated form. A few concretions of calcium carbonate are present in the upper part of this layer.

The material in each layer passes gradually into the underlying material.

Hydrogen-ion determinations on samples of Fairview silty clay loam are given in table 9.

TABLE 9.—*Hydrogen-ion determinations on a profile of Fairview silty clay loam in Major County, Okla.*

Sample No.	Depth	pH	Sample No.	Depth	pH	Sample No.	Depth	pH
	Inches			*Inches*			*Inches*	
452835	0 - 1	7.0	452838	6–12	8.1	452841	50- 64	8.2
452836	1 - 2½	7.1	452839	12–18	8.4	452842	64- 84	(1)
452837	2½- 6	7.4	452840	18–50	8.0	452843	84–110	7.9

[1] Not sent in from the field.

Developed on the smooth beds, in places in association with the Rusk and Fairview soils, are brown claypan soils of the Calumet series. These are similar in character to the Foard soils but are underlain by more permeable parent materials. The horizon in which calcium carbonate is accumulated is 2 or 3 feet thick and in places lies within 2 feet of the surface. The parent material contains some crystals of gypsum and possibly contains other soluble salts in larger amounts than do the parent materials of most of the other soils developed on old alluvium.

The Reinach soils, formed from alluvium made up of "Red Beds" materials, are reddish-brown or red soils on smooth-lying land, typically underlain by layers of sandy materials. Little or no accumulation of calcium carbonate is evident; in places the subsoils are calcareous, although the surface soils, as a rule, are not calcareous. The Canadian soils are brown noncalcareous soils of the terraces, which are rather permeable but have little or no accumulation of calcium carbonate. The soils of this group—the soils developed from old alluvium—are smooth, generally medium textured, deep, and freely permeable for the most part, but they are not so porous as to leach rapidly. They are rather productive and suited to a large number of crops.

The soils of flood-plain alluvium belong to the Lincoln and Yahola series. The parent materials of the Lincoln soils are washed chiefly from calcareous soils or formations of the higher plains. These soils are light colored, in places imperfectly drained, and in some areas have an excess of soluble salts that are injurious to plants. The Yahola soils comprise red calcareous soil materials washed mostly from "Red Beds" material, the Vernon soils, and other red calcareous soils of the upland plains. The subsoils of both the Lincoln and Yahola soils are rather loose and sandy and as a rule are not so heavy textured as the surface soils.

Mechanical analyses of three soils are given in table 10.

TABLE 10.—*Mechanical analyses of three soils in Major County, Okla.*

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Calumet silty clay loam:								
452815	0 - 1	0.6	1.1	2.2	5.0	15.1	50.5	25.4
452816	1 - 2½	.9	1.2	2.1	5.0	16.6	50.1	24.2
452817	2½- 4½	.7	1.0	2.1	4.2	13.0	47.4	31.7
452818	4½- 8	.0	.6	1.8	2.9	11.1	44.3	39.2
452819	8 - 24	.0	.6	1.3	2.2	7.1	26.8	62.1
452820	24 - 33	.4	.6	.9	2.3	7.1	34.3	54.3
452821	33 - 45	.8	1.0	1.0	2.4	6.1	36.3	52.3
452822	45 - 57	.4	.8	1.1	2.5	7.3	36.7	51.1
452823	57 - 62	.3	.9	1.4	2.6	7.0	38.4	49.4
452824	62 - 96	.3	.9	1.7	3.4	8.1	39.6	45.9
452825	96 -110	.2	.2	3.4	4.6	9.2	41.0	41.3
Reinach clay:								
452807	0 - 3	.1	.2	.1	.9	3.6	28.1	67.0
452808	3 - 11	.1	.1	.2	1.2	7.8	50.1	40.5
452809	11 - 23	.0	.1	.1	.6	4.0	54.3	40.8
452810	23 - 34	.0	.2	.2	1.2	10.5	44.5	43.4
452811	34 - 50+	.1	.6	2.7	6.6	5.1	30.3	54.5
Pond Creek silt loam:								
4528137	0 - 1½	.1	.4	.4	1.9	14.9	62 7	19.6
4528138	1½- 6	.0	.3	.3	1.0	11.8	65.6	20.9
4528139	6 - 12	.0	.3	.3	1.0	13.5	63.0	21.8
4528140	12 - 22	.1	.2	.3	.7	10.4	62.4	25.9
4528141	22 - 36	.0	.3	.4	.9	8.9	55.2	34.3
4528142	36 - 58	.0	.4	.4	.8	6.1	44.6	47.6
4528143	58 - 64	.0	.5	.6	1.2	10 7	45.3	41.7
4528144	64 - 72+	.1	.6	.7	1.4	10.5	41.7	44.9

SUMMARY

Major County, in northwestern Oklahoma, comprises an area of 954 square miles, or 610,560 acres.

This county lies at the eastern edge of the region of pedocalic soils. Physiographically, it consists of two plains separated by an escarpment extending from the northwestern corner to the south-central part. The higher plain lies west of the escarpment and is deeply dissected along its eastern edge. Some distance away from the escarpment the plains are smooth, except for a small area of broken land in the northwestern part of the county where they are relieved by rolling sandy land. All the surface drainage is effected through the Cimarron and North Canadian Rivers and their tributaries. There is comparatively little run-off in the sandy sections, as the deep permeable sandy soils absorb nearly all of the rain water. Imperfect drainage prevails only in comparatively small scattered basinlike areas within the sandy lands and here and there on the flood plains.

The first permanent settlement was made at the time the Cherokee Strip was opened in 1893. The population of the county, according to the 1930 census, is 12,206. Good transportation facilities are available and rural mail delivery routes reach almost all sections.

About 53.4 percent of the total land area is covered by soils that are generally suited for cultivation. The rest of the land is used chiefly for grazing. Thirty-six soils, eight phases of soils, and four miscellaneous land types are mapped. Soils suited for cultivation are of five different groups.

All the comparatively heavy textured soils are placed in two groups. Because of the fine texture of their subsoils, conditions for conserving moisture are favorable, and this feature, together with their smooth surfaces, causes these soils to be used principally for the

production of wheat. The soils having friable surface soils and moderately heavy textured subsoils cover an area of 156.8 square miles. These soils have developed to a great depth and are, in general, the most productive soils for wheat in the county. They are chiefly the silt loam, fine sandy loam, and very fine sandy loam members of the Pond Creek, Grant, St. Paul, Reinach, Rusk, Weymouth, and Foard series. The other comparatively heavy textured soils are those with heavy-textured surface soils as well as heavy-textured subsoils. They cover an area of 81.1 square miles. These soils are not deeply developed and are less productive for wheat than those of the first group. They are mainly the silty clay loam and clay members of the Rusk, Fairview, Foard, Calumet, and Reinach series.

Soils having sandy surface soils and moderately heavy to light-textured subsoils are members of two groups but are, in general, associated. They are the soils with sandy surface soils and moderately heavy textured subsoils, namely, the fine sandy loams of the Pratt, Reinach, Carwile, and Carmen series, and the soils with sandy surface soils and subsoils, mostly the loamy fine sands and fine sands of the Pratt, Tivoli, Reinach, and Canadian series. The soils of the first group cover an area of 61.7 square miles and are well suited for the production of grain sorghums, feed crops, and to some extent, for wheat. Those of the second group, which cover an area of 159.4 square miles, are used principally for the production of grain sorghums, feed crops, and other miscellaneous crops, although their productivity in general is lower than that of the sandy soils with moderately heavy textured subsoils.

The arable soils of the bottom lands, with a total area of 50.4 square miles, form another group. These are calcareous soils of the Yahola and Lincoln series. They comprise recently deposited soil materials washed from the uplands. Their position only a few feet above the normal flow of streams subjects them to overflow. Water drains away, in most places, however, within a few hours after the streams subside, and, in those areas not cut by channels, the soils are suited for cultivation. The cultivated areas include some of the most productive soils for alfalfa and grain sorghums in the county.

Soils and land types that are unsuited for cultivation, owing to instability under cultivation, unfavorable relief, or other factors, are used mainly for pasture. Their total area is 444.6 square miles. The most extensive members of this group are the dune phases of the Tivoli and Pratt soils, the eroded Vernon soils, rough broken land, and riverwash.

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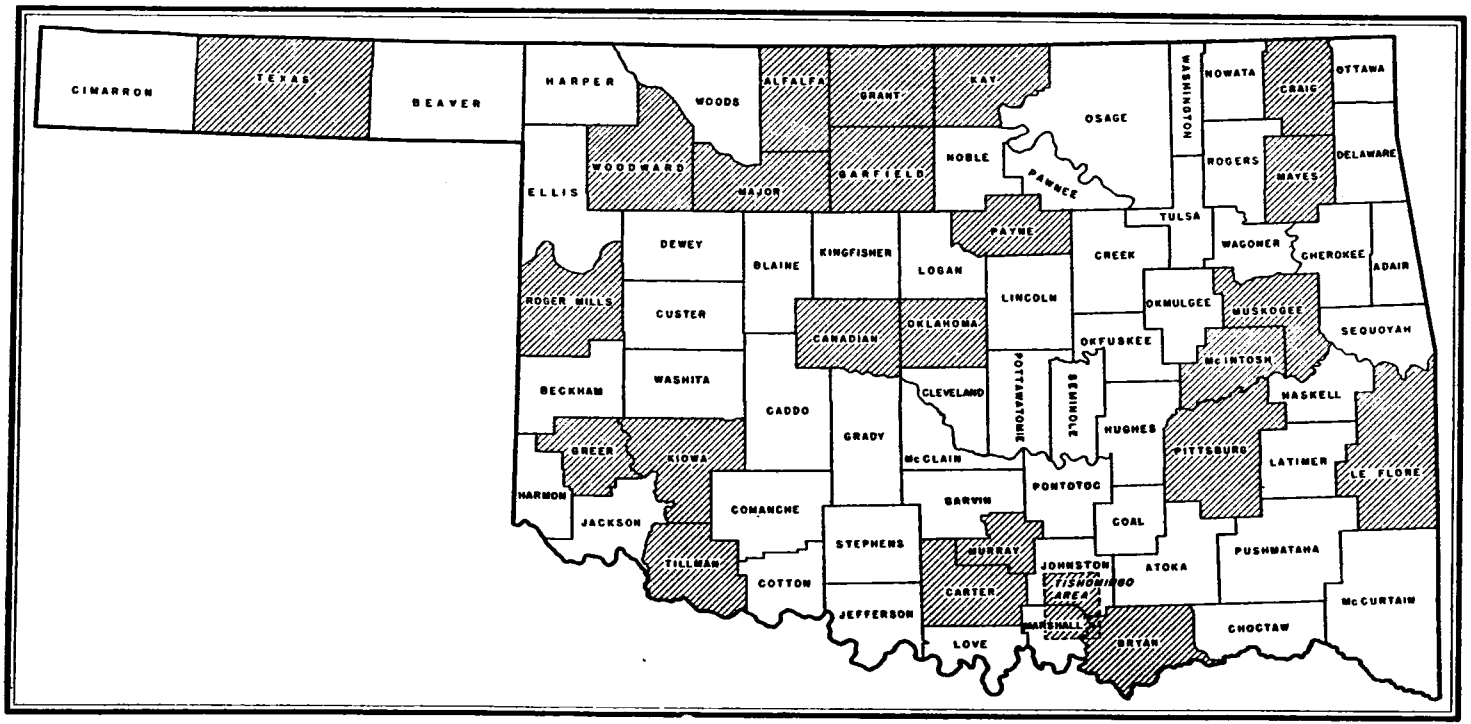

Areas surveyed in Oklahoma, shown by shading.

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SOIL MAP
MAJOR COUNTY
OKLAHOMA

OKLAHOMA AGRICULTURAL EXPERIMENT STATION
C. P. BLACKWELL, DIRECTOR
AGRONOMY DEPARTMENT
H. J. HARPER, PROFESSOR OF SOILS


CONVENTIONAL SIGNS
LEGEND
Calumet silty clay loam Cs
Reinach loamy fine sand Rl
Canadian loamy fine sand Ca
Reinach fine sandy loam Rf
Canadian very fine sandy loam Cv
Reinach very fine sandy loam R
Carmen fine sandy loam Cf
Reinach silty clay loam Re
Carwile fine sandy loam Cm
Reinach clay Rc
Carwile clay Cc
Rc Heavy-subsoil phase
Enterprise loamy very fine sand El
Rusk very fine sandy loam Ru
Fairview silty clay loam Fa
Rusk silt loam Rm
Fa Flat phase
Rusk silty clay loam Rs
Foard very fine sandy loam Fv
St. Paul loamy very fine sand Sl
Foard silty clay loam Fs
St. Paul very fine sandy loam Sv
Grant very fine sandy loam Gv
Tivoli fine sand Tv
Lincoln very fine sand Lv
Tv Dune phase
Lincoln loamy very fine sand Ll
Vernon very fine sandy loam, Broken phase Vf
Lincoln silt loam Ls
Vernon clay, Eroded phase Vc
Lincoln clay Lc Imperfectly drained phase
Vernon-Fairview complex V
Lc Saline phase
Weymouth fine sandy loam Wf
Nash very fine sandy loam Nv
Weymouth very fine sandy loam Wv
Pond Creek silt loam Ps
Yahola loamy very fine sand Yl
Pratt loamy coarse sand Pc
Yahola fine sandy loam Yf
Pratt loamy fine sand Pl
Yahola very fine sandy loam Y
Yahola clay Yc
Pl Dune phase
Pratt fine sandy loam Pr
Rough broken land RbQ Quinlan soil material
River wash Rv
RbV Vernon soil material
Depressions
Saline spots S
Note that similar soils are shown with the same color but with different letter symbols.

William T. Carter, Inspector, District 4.
Soils surveyed by W. H. Buckhannan, U. S. Department of Agriculture, in charge, and O. H. Brensing and C. F. Fisher, Oklahoma Agricultural Experiment Station.

Scale 1 inch=1 mile

Polyconic projection, 1927 North American Datum.
Horizontal control by U. S. C. and G. S.
10000 foot grid based upon Oklahoma (North) system of plane coordinates.
Surveyed in 1934-36. Series 1936.